# NEW UPPER CARBONIFEROUS NON-MARINE LAMELLIBRANCHS

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ABSTRACT. Two anthracosiid assemblages from the upper part of the *lenisulcata* Zone of the Leinster (Castlecomer) Coalfield, Ireland, one from Co. Tipperary (Slieveardagh) Coalfield, Ireland, and one from Glynneath, Glamorgan, South Wales, have been measured and are extensively illustrated. The results bear on relationships between the morphological species *Carbonicola extenuata*, *C. crispa* and *C. proxima* Eagar, *C. extima*, and *C. pontifex* spp. nov. The latter are described with *Naiadites hibernicus* sp. nov. from the Upper Namurian of Leinster, and *Anthraconaia fugax* sp. nov., a name for shells from the *communis* Zone of the Burnley Coalfield first described by Hind (1893) who referred them to *Anthracomya wardi* (Salter). Notes are added on *Anthraconaia fabaformis* (Kinahan) from Leinster and Tipperary. The work has led to the correlation of Ward's Seam of the Leinster Coalfield with the Upper Glengoole Coal of Tipperary. Near the top of the *lenisulcata* Zone, faunas of *Carbonicola* suggest the approximate correlation of the Coalbrook Band of Tipperary, the Glynneath ($C_1$) Band and the Norton Musselband of the East Pennines.

SOME non-marine faunas from horizons in the Leinster and Tipperary Coalfields (see Eagar in Nevill 1956, 1962) are described in ascending sequence (text-fig. 1). The faunas are discussed *vis-à-vis* the Pennine succession where, in most cases, material from supposedly equivalent horizons is known mainly from borings and is consequently limited (Eden 1957, Eagar 1956). The Coalbrook Band of Tipperary is also compared with that of Glynneath (Leitch, Jones, and Owen 1958, p. 465, $C_1$). The systematic description of new species forms the second part of the paper.

I am grateful to Dr. W. E. Nevill, of University College, Cork, for advice on localities and assistance in the field; also to Mr. M. V. O'Brien, Director of the Geological Survey of Ireland, who permitted me to borrow specimens and to reproduce parts of the records of the Copley's Bridge and Kilgorey Boreholes and the sketch-map of text-fig. 1. Officers of Mr. O'Brien's staff have given me courteous assistance, especially Mr. M. O'Meara and Miss Dilys Jones. For the loan of material I am also indebted to Dr. F. W. Anderson, of the Geological Survey of Great Britain, to Mr. W. D. Ware and to the Trustees of the British Museum (Natural History). Mr. D. G. Jones, of King's College, University of London, very kindly collected non-marine material for me from a locality near Glynneath.

## A *NAIADITES* FAUNA OF UPPER NAMURIAN ($G_1$) AGE IN LEINSTER

Small *Naiadites*, including some uncrushed specimens, have been found with occasional *Carbonicola sp.* in Aghamucky Borehole, from 32 to 25 feet below the base of the marine band yielding *Gastrioceras cumbriense* Bisat (text-fig. 1). The same fauna is apparently represented by poorly preserved *Naiadites* with *Carbonicola* aff. *pseudacuta* and *C.* cf. *lenicurvata* Trueman 28 feet below the *G. cumbriense* horizon in Jarrow Borehole, 1¾ miles north-north-east of Aghamucky (see Nevill 1956, pl. iii). The fauna is also represented in Killeshin Glen, towards the eastern margin of the coalfield (Eagar in Nevill 1956, p. 12).

The *Naiadites* fauna consists of small, sharply beaked, carinate to subcarinate shells having a medium degree of obliquity and with umbones which do not rise appreciably

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above the line of hinge of the shell (text-fig. 14A–D, G–J; Plate 47, figs. 16, 17). Such forms, which have been compared with *Naiadites productus* and *N. subtruncatus* Brown, have long been known from beds of the uppermost Namurian and of the lower part of the *lenisulcata* Zone of the Pennine Coalfields (Wray and Melmore 1931, p. 41; Wray and Trueman 1931, p. 71; Eagar 1953*a*, pp. 173–4; Trueman and Weir 1955, p. 232, pl. xxx, fig. 39). A new species, *Naiadites hibernicus*, representative of this stratigraphically useful group of shells, is described in the systematic section, where the variation of the fauna is discussed in detail.

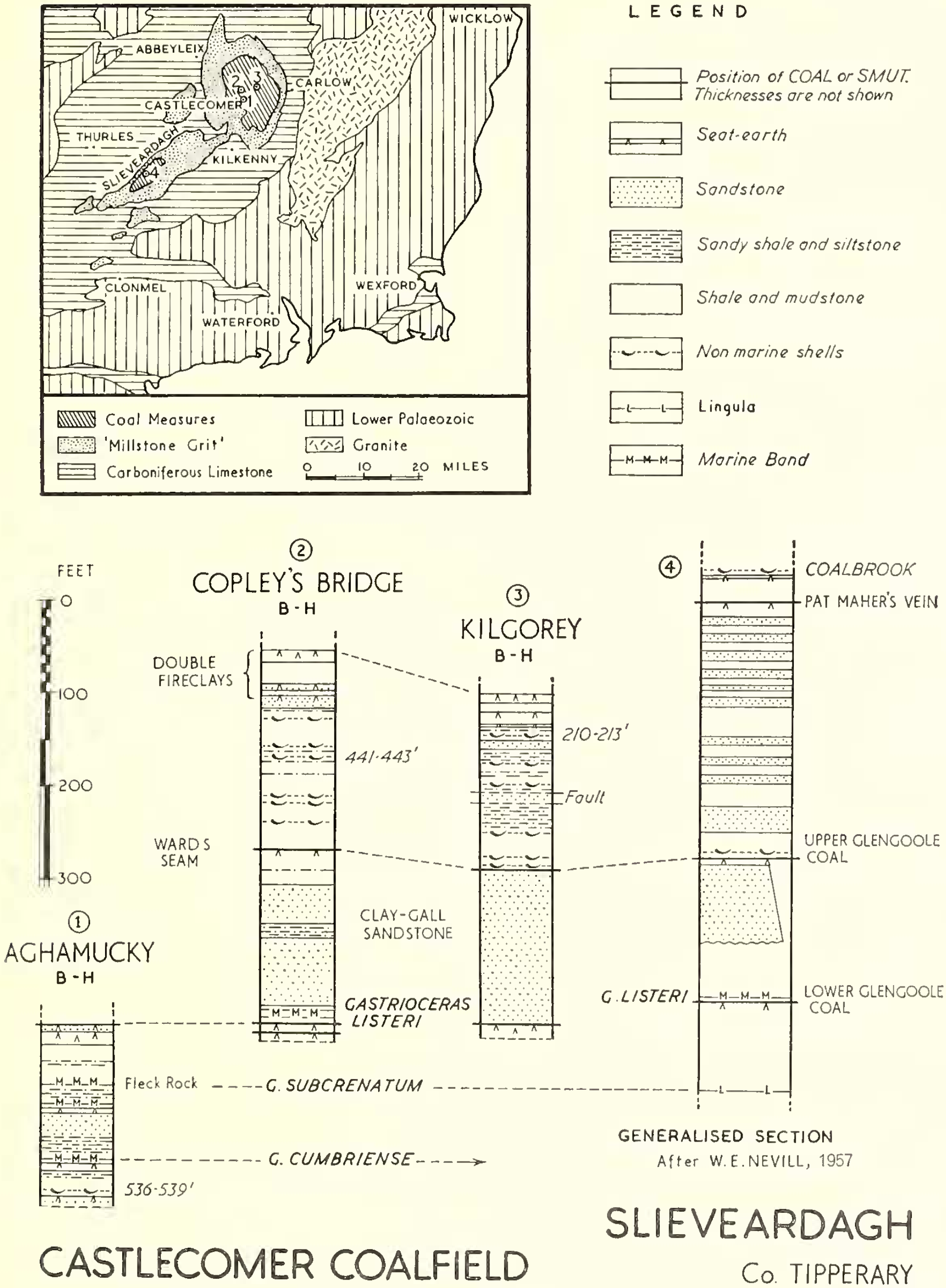
## FAUNAS OF WARD'S SEAM AND THE UPPER GLENGOOLE COAL

Some shells from the *Anthraconaia* fauna above Ward's Seam of the Leinster Coalfield were illustrated by Hind (1896, pl. xvii, figs. 3–7). The fauna is widely variable, notably in the lateral outline of the larger shells (with lengths greater than 25 mm.) which may be found locally up to 60 feet above the coal. Many of the smaller specimens, however, especially those which occur as uncrushed internal moulds of juxtaposed valves in the foot or so of measures immediately overlying the coal, have distinctive solid form and are referable to the group of *Anthraconaia fabaformis* (Kinahan) (Plate 47, figs. 1*a–c*, 2*a*, *b*). The umbones have well-defined tips which in dorsal view are closely set, and in lateral view rise appreciably above the median ridge representing the line of junction of the hinge-plates posterior to the umbo. The anterior end is blunt in lateral view and evenly swollen, the relatively high anterior lobe bearing a small shallow lunule with sharply defined edges. The sides of the mould are gently swollen, being without trace of the oblique carinal tumescence or line of turn on the surface which characterizes *Anthraconaia*-like forms of the *lenisulcata* Zone in Britain.

The shell of *Anthraconaia fabaformis* was obviously thin and quite commonly appears to have been broken or distorted in the region of the posterior inferior angle, so that there is often a suggestion of gape along the posterior margin.

The foregoing characters of shell and mould have been found at no other horizon in the Leinster succession, nor are they known on any other horizon in the *lenisulcata*, *communis*, and *modiolaris* Zones of the British Coal Measures. The same characters, however, reappear in the larger specimens of twenty *Anthraconaia*, ranging in length from 4 to 12 mm. (Plate 47, fig. 3) collected by Dr. W. E. Nevill from spoil heaps over the outcrop of the Upper Glengoole Coal of the Slieveardagh Coalfield near Bregaun Hill and Commons Village. Both the Leinster and Tipperary faunas contain also *Naiadites hibernicus* sp. nov. The Upper Glengoole Coal lies about the same distance above the *Gastrioceras listeri* Marine Band as does Ward's Seam (text-fig. 1) and both coals lie above sandstones of comparable type and thickness (Nevill 1957, p. 317). The faunal comparison thus strongly supports stratigraphical evidence that the Upper Glengoole Coal should be correlated with Ward's Seam.

The fauna from Bregaun Hill includes one internal mould (Plate 47, fig. 4) which shows what appears to be an impression of a long lamellar groove on the hinge running parallel to its edges from about 3 mm. behind the umbo (where the vertical median ridge is broken) to about 5 mm. behind it, where the groove becomes shallow and dies out. The structure appears comparable with the grooves on the mould of *Anthraconaia modiolaris* figured and discussed by Hind (1895, pl. xiv, fig. 32) who supposed the lamellar structure to indicate a long posterior lateral tooth. Discussing the specimen, Dr. J.




TEXT-FIG. 1. Parts of boreholes and a section in the Lower Coal Measures and uppermost Millstone Grit of south-east Ireland. Thicknesses of coals are not shown to scale.

Weir (*in litt.* to the author, 1957) considered that the rectilinear grooves which have been seen on the rarely exposed hinge region of *Anthraconaia* from the *modiolaris* Zone were homologous with the better-known grooves on the ligamental area of *Naiadites* (for example Dix and Trueman 1931, fig. 6; Trueman and Weir 1955, text-fig. 30c); and that they were not articular but ligamental in origin. *Anthraconaia* appears to have been edentulous, with myalinid type of hinge pattern. Hinge-plates of *Anthraconaia oblonga* (Wright), subsequently obtained from the Lower *similis-pulchra* Zone of Wakefield Westgate Brickworks (Eagar and Rayner 1953), reveal similar structures to that first observed by Hind, but fully support the contention of Dr. Weir and the writer that the grooves contained part of the ligament. The Tipperary hinge is not only important in supporting evidence from previously discovered rare specimens, it also provides the earliest record indicating what appears to be a myalinid feature amongst the varied group of non-marine shells included within the genus *Anthraconaia*.

## FAUNAS OF *CARBONICOLA EXTENUATA*

(*a*) *The material and its separation.* Nine-inch cores from Kilgorey Borehole (text-fig. 1) have yielded well-preserved *Carbonicola* in abundance from 23 to 25 feet below the top of the lower main seam of the Double Fireclays and approximately 140 feet above Ward's Seam. Both small and large shells, apparently constituting two separate bio-species (text-fig. 2), occur together in courses, an inch or so in thickness, in medium to coarse-grained dark shaly mudstones (*c.* Grades 4 and 5 of Eagar 1947, p. 13). On currently accepted criteria (e.g. Broadhurst 1959, p. 533, Eagar 1961, p. 137), the band evidently represents a life assemblage. Although nearly all the larger individuals are slightly smaller than the holotype of *Carbonicola extenuata* Eagar (text-fig. 2, text-fig. 3L–O, Q–W), a number of forms, notably those illustrated as text-fig. 3V, S, and T, show the essential characters of this species. Several other shells compare with previously figured variants of the *C. extenuata* group (e.g. in text-fig. 3 and Eagar 1956, fig. 6, compare respectively Q with *f*, O with *g*; compare also text-fig. 4G with Eagar 1956, fig. 6*e*).

The holotype of the new species *Carbonicola extima* (text-fig. 3B; Plate 48, fig. 2) has been selected from the smaller shells and is described below; also the separation of the two groups is briefly discussed. In text-fig. 2, the fitted lines represent the following equations:

$$H = 0{\cdot}487\,L - 0{\cdot}97 \qquad \text{(i)}$$

for the *Carbonicola extenuata* group, and

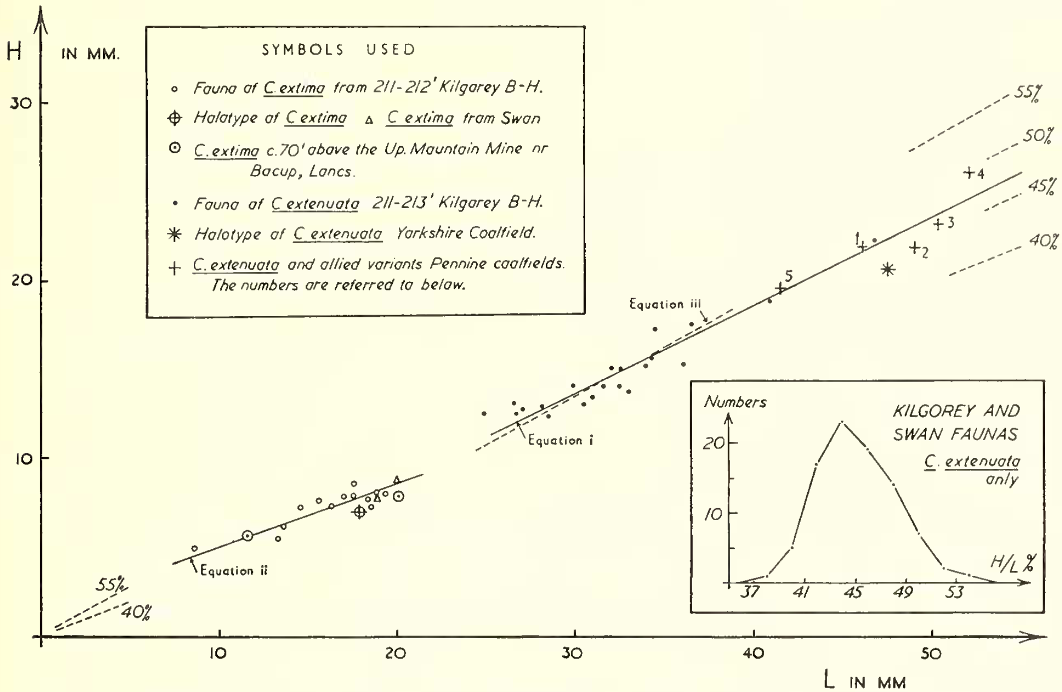
$$H = 0{\cdot}355\,L + 1{\cdot}46 \qquad \text{(ii)}$$

for the small shells including *C. extima*.

Calculation of the statistic *z* (Imbrie 1956, p. 237) indicates that the slopes, as well as the displacements of these lines, are significantly different at the 95 per cent. level.

A second fauna, containing *C. extenuata* (text-fig. 4; Plate 48, fig. 1) and occasional *C. extima* (Plate 48, fig. 3), was collected on what appears to be the same horizon as that of Kilgorey (about 150 feet above Ward's Seam) in a stream section near Swan village, $4\frac{3}{4}$ miles north-north-west of Kilgorey Borehole. Shells occur through 13 inches of rather coarsely grained ferruginous mudstone and ironstone, much of the material consisting of uncrushed internal and external moulds. Although most of the shells evidently represent a life assemblage, some of the single valves are presumed to have suffered a small amount of movement before burial. Plotting of the height and length measurements of the assemblage of sixty-eight internal moulds, two specimens of *C. extima* being omitted, gave a straight path with fitted line having the equation:

$$H = 0{\cdot}542\,L - 2{\cdot}64 \qquad \text{(iii)}$$



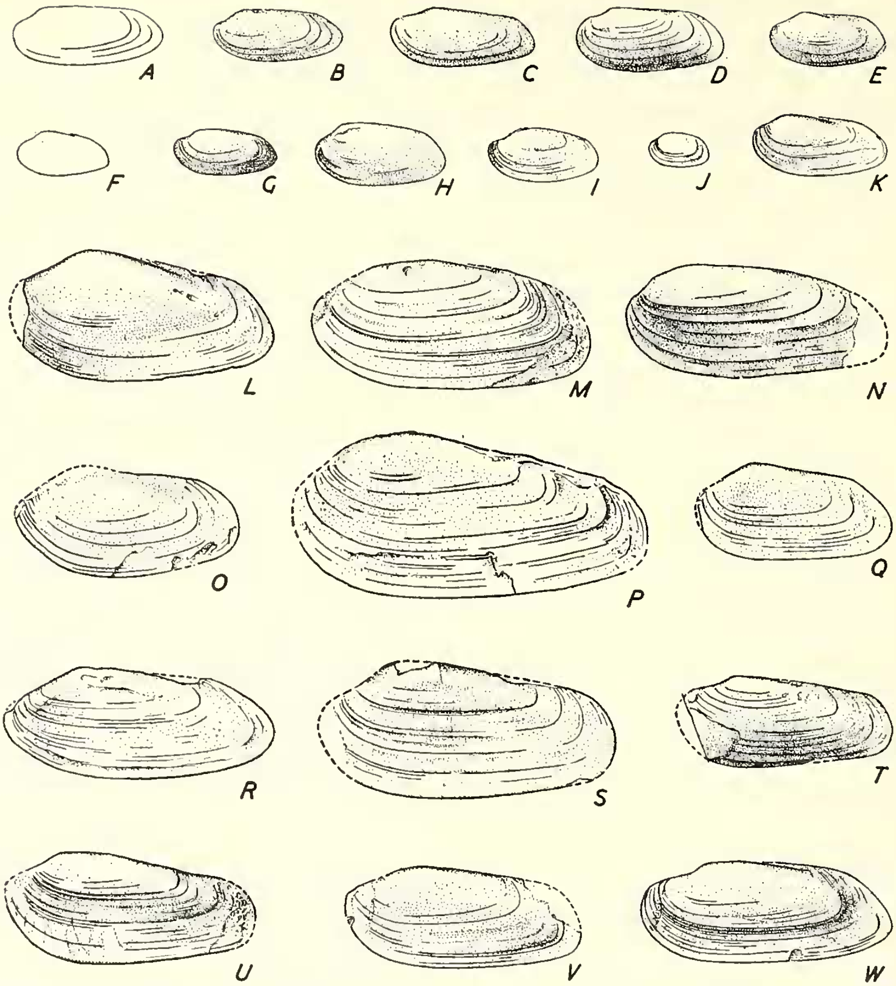

TEXT-FIG. 2. Height plotted against length of shells in assemblages of *Carbonicola* from below the Double Fireclays, Kilgorey Borehole, and at Swan, Castlecomer Coalfield, with comparative measurements of material from the Pennines. Of the numbered shells of *C. extenuata*, 1, 2, 4, and 5 are figured by Eagar 1956, figs. 6*i*, 7*e*, 7*a*, and 6*a* respectively (M.M. LL1221, 1205, 1206, 1223). 3, G.S.Bb.411, is cited (Eagar 1956, p. 348).

Inset: frequency polygon for height/length ratio for *C. extenuata* from Kilgorey and Swan.

This line (text-fig. 2, equation (iii)) is not significantly different from that of the Kilgorey shells (equation (i)). In the ensuing account of the faunas the Swan and Kilgorey shells are treated together.

(*b*) *General description of the fauna.* A number of shells from Swan provide perfect impressions of the hinge-plate which, with its striated irregular surface of slight mounds and larger, deeper depressions, or sockets, is typical of the *Carbonicola fallax* group (*sensu lato*: Eagar 1946, p. 3).

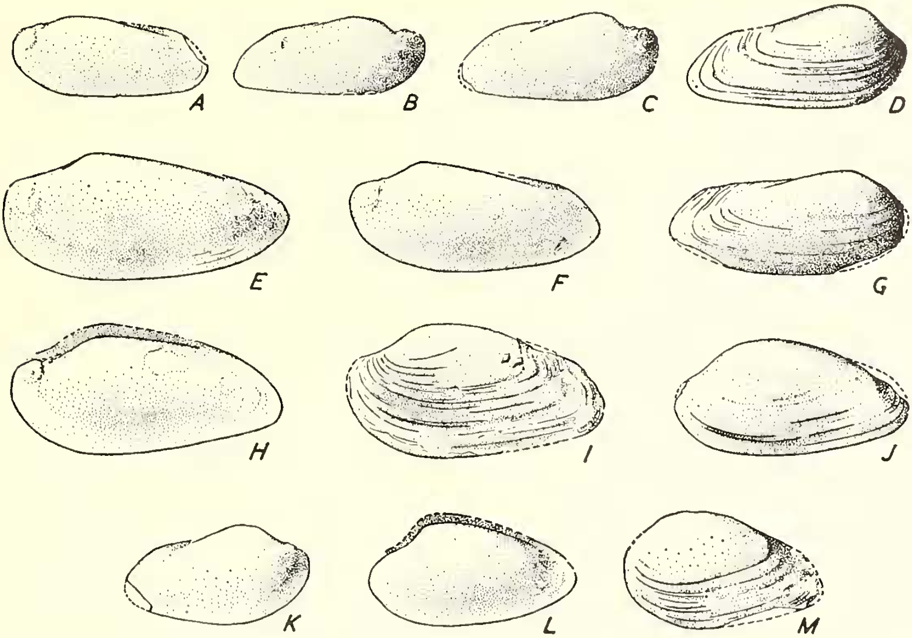
As a whole the fauna (Table 1) consists of medium- to large-sized, elongate, rather gently swollen forms which lack the carina and usually the turn on the surface of the shell which characterizes members of the *C. fallax* group from the lower and middle *lenisulcata* Zone of Britain (Eagar 1954, pl. i, figs. vii, ix, x). The ventral margin of the shell curved invariably and the tapered posterior end is truncated, typically rather




TEXT-FIG. 3. Faunas of *Carbonicola extima* sp. nov. (A–K), and *C. extenuata* Eagar (L–W): A, B (holotype), *C. extima*; C–I, K, *C.* aff. *extima*; J, *C. extima* sp. juv.: S, T, V, *C. extenuata*; M, N, P, R, U, W, *C.* aff. *extenuata*; L, O, Q, *C.* cf. *obliqua* Wright. A, F, from *c.* 70 ft. above the Upper Mountain Mine, Bacup district, M.M. LL1195A, D. Remainder from 211 to 213 ft., Kilgorey Borehole, I.G.S. K211/1C, E, 2A, C, 3A–C, 4A, 5A, D, F, G; K212/2A, D, F, 3A, B, D, E, 4A; K213/2A. Shells B, D, I, J, L, P, Q, and W drawn as mirror images. Approximately natural size.

bluntly. The umbo and anterior end appear somewhat variable, even when full allowance is made for considerable thickness of shell over the umbo (compare the outlines shown in text-fig. 4C and D) and for uneven crushing (as seen in the shells of text-fig. 3M, O, R). The inflated umbo of text-fig. 4D is uncommon, the umbones being typically low and without inflation. The anterior end is short, ranging mainly between 19 and 26 per cent. of the length. It is bluntly rather than fully rounded and the anterior lobe is high.

All the prevalent features of the fauna summarized above are characteristic also of the holotype of *Carbonicola extenuata*, dimensions of which are plotted in text-fig. 2. It will




TEXT-FIG. 4. Fauna of *Carbonicola extenuata* from near Swan, Leinster Coalfield. A, *C. extenuata*; B, C, F–H, *C.* aff. *extenuata*; D, *C.* cf. *obliqua*; E, *C.* cf. *acuta* (J. de C. Sowerby). I, J, M, *C.* cf. *proxima* Eagar; K, L, *C. sp.* A–D, G. I, K–M, M.M. LL2682–90; E, F, H, J, T.C. CS/II/1A, D, 2A, F. Approximately natural size.

be seen that other Pennine specimens of this species also fall along the extrapolated line of the Kilgorey fauna, and that the holotype lies towards the edge of the scatter.

In Table 1 it will be noticed that the mean value of obesity (T) for the Swan assemblage

TABLE 1

| | *Length in mm.* | | *H/L ratio %* | | *T/L ratio %* | | *A/L ratio %* | |
|---|---|---|---|---|---|---|---|---|
| | *Range* | *Mean* | *Range* | *Mean* | *Range* | *Mean* | *Range* | *Mean* |
| Kilgorey | 24·8–46·8 (21) | 32·3 | 41·8–50·9 (21) | 45·6 | . . | . . | 18·0–26·4 (10) | 23·4 |
| Swan | 20·0–36·5 (68) | 29·7 | 39·0–54·0 (68) | 45·2 | 19·5–39·4 (44) | 28·2 | 17·5–32·5 (54) | 23·8 |
| Holotype | 47·5 | | 43·0 | | 22·0 | | 21·5 | |

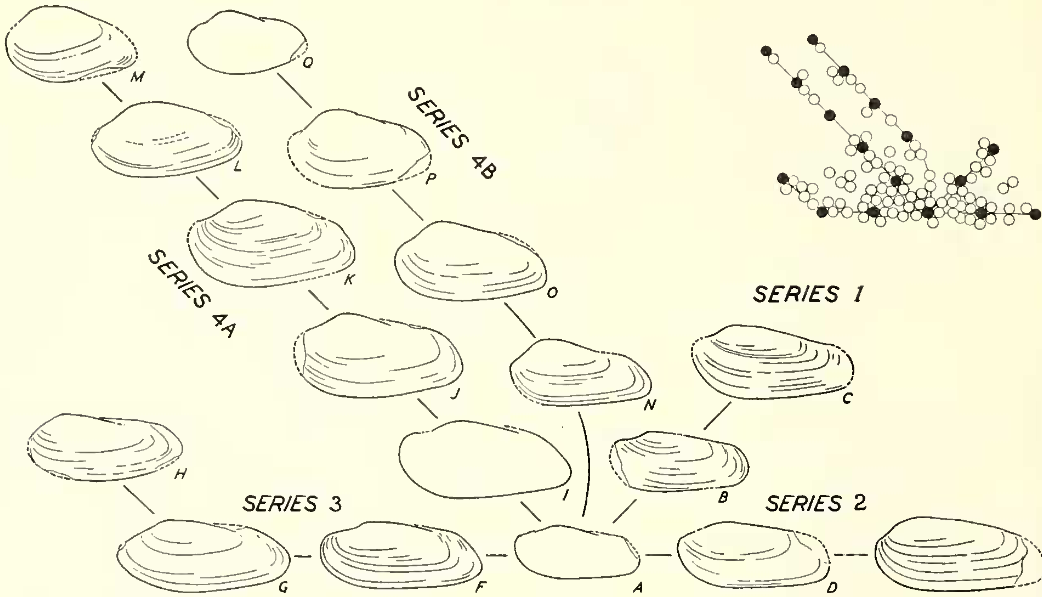
Irish faunas of the *Carbonicola extenuata* group compared with the holotype of this species, from Elland, Yorkshire.

All measurements have been made in the standard directions defined by Davies and Trueman (1927, p. 212). Figures in parentheses denote the numbers of specimens available for measurement.

is appreciably higher than the figure for the holotype of *C. extenuata*. Part of this difference may be attributable to the fact that the holotype is larger than the largest members of the Swan assemblage in which, as is typical in faunas of the *lenisulcata* Zone (Eagar 1947, p. 22), increase in size is correlated with decrease in obesity.

(*c*) *Pattern of growth.* As in most Pennine specimens of the *Carbonicola extenuata* group, a small degree of oblique growth took place in the early stages of the development of many of the Leinster shells (e.g. text-fig. 3N), being most marked in Series 4A of text-fig. 5. The trend towards oblique growth appears absent, however, in certain elongate forms (e.g. text-fig. 3S).

Undoubtedly the height/length ratio of the Leinster faunas as a whole increased considerably in the later stages of growth. For instance, measurement reveals that ten shells




TEXT-FIG. 5. Variation and distribution diagrams for *Carbonicola extenuata* from Kilgorey and Swan, Leinster Coalfield. In the distribution diagram black circles show the positions of the figured variants. Outlines from text-figs. 3 and 4, including also M.M. LL2691 (O) and T.C. CS/11/2G (P). ×0·635.

from Kilgorey at a mean length of 23·1 per cent. had a mean H/L ratio of 36·7 per cent., comparing with 33·1 and 44·5 per cent. respectively at the termination of growth. These figures show precisely the pattern of growth which has already been noted in the *C. extenuata* group in the Pennines (Eagar 1956, p. 362).

It will be apparent that the lines representing the growth of individual shells in terms of height and length are considerably steeper than the fitted lines of equations (i) and (iii) of text-fig. 2 and that many of them must cross these lines. The difference between lines of individual growth and the fitted line, or mass curve, of the assemblage has been noted and discussed before (Eagar 1953*b*, p. 153). The latter is an empirical formula, of proved value in the systematics of Carboniferous non-marine shells, but with a significance which is not yet understood.

(*d*) *Variation.* In the pictograph of text-fig. 5 the norm (A) is a little shorter than the holotype of *Carbonicola extenuata.* Tapering of the lateral outline of the shell towards the posterior with blunt truncation and a slight increase in subumbonal depth leads to Series 1 (B, C). The same morphological trends, but without increase in the height of the shell, may be seen in Series 2 where, in (E), there is further elongation. In Series 3 the posterior truncation becomes oblique, the posterior ventral angle is sharpened (F) and the ventral margin becomes more rounded, with the production of long, oval forms. Further sharpening of the posterior-ventral angle may be seen in text-fig. 4F and E, the latter shell differing from *Carbonicola acuta* (J. Sowerby) in being more elongate and with lower umbones. In Series 4A of text-fig. 5 the shells are again characterized by oblique truncation with a fairly well-developed posterior ventral angle, but in progression outward from the norm the shells show increase in H/L and A/L ratios; at the same time the ventral margin becomes curved so that the later forms (K, M) approach, but do not reach, the outline of *Carbonicola proxima* Eagar. In this Series the umbones become increasingly prominent in lateral outline but remain relatively narrow and show a slight forward tilt due to oblique growth (see preceding section). In Series 4B the same general changes in lateral outline take place, but the umbones become inflated and the ventral margin finally attains greater curvature. The shell illustrated as text-fig. 5N and 4D compares with *Carbonicola obliqua* Wright and the remaining shorter forms of this Series also show some similarity to certain variants of the *C. obliqua* assemblages from above the horizon of the Lower Foot Mine, Goyt's Moss, Derbyshire. For instance, in text-fig. 5 and Eagar 1956, fig. 5, compare respectively O with *p*, Q with *k*.

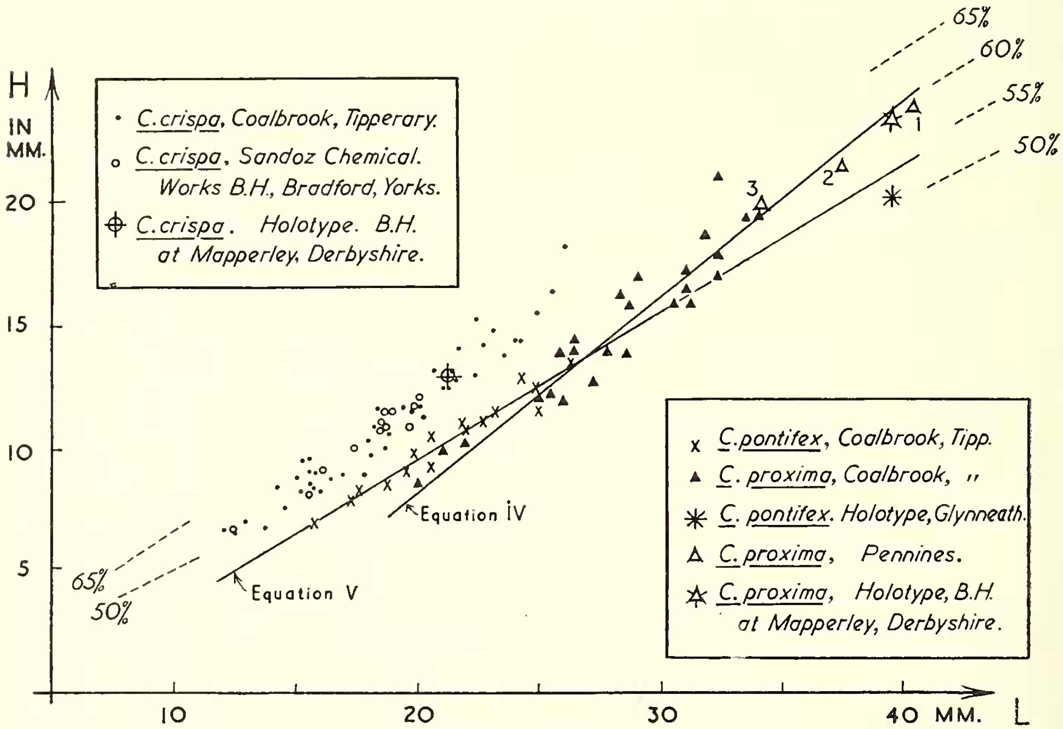
Although the short shells of Series 4A and B form the more striking variants of the Leinster assemblage, they are considerably less numerous than the longer forms. The distribution diagram (text-fig. 5, inset) indicates that the mode lies around the norm, especially between the shells (A), (F), (I), (B), and (D), and that Series 1 and 3 are more strongly represented than the end forms of Series 2.

(*e*) *Comparison with Pennine faunas*. Several individual variants of the Leinster faunas of *Carbonicola* compare, often closely, with shells from the middle and upper part of the *lenisulcata* Zone of the Pennine Coalfields, that is from horizons between the Lower Mountain Mine (Plate 48, fig. 5*a*, *b*) and the Norton Musselband. The best comparisons may be found between modal variants of the Leinster faunas and Pennine shells from the upper part of the cyclothem immediately preceding Tonge's Marine Band. On this horizon *C. extenuata* reaches its maximum (Eagar 1956, pp. 348–50) and comparison is particularly satisfactory with material from Jewel Mill Borehole in the Burnley Coalfield (Earp and Magraw 1957, p. 26; G.S.M. JE1531–1608). The known range of *Carbonicola extima* sp. nov. in the Pennines also suggests this horizon as the most likely correlative of the Leinster faunas.

## THE COALBROOK BAND, TIPPERARY

(*a*) *The material and its separation*. At a small exposure in Poynstown, one mile north of Coalbrook Village, Tipperary, moderately well to poorly preserved anthracosiid shells may be found through 16 inches of grey ferruginous shaly siltstone and silty mudstone. This horizon, referred to as the Coalbrook Band, has been estimated by Mr. O'Brien to lie about 550 feet above the *Gastrioceras subcrenatum* Marine Band and about 40 feet above Pat Maher's Vein (text-fig. 1). The fauna is referable, in order of abundance, to *Carbonicola crispa* Eagar (text-fig. 8F, G), *C. proxima* (text-fig. 9B), and *C. pontifex* sp. nov. (text-fig. 11B). Amongst 190 shells there is also a single specimen of *?Anthracosphaerium sp.* (text-fig. 11H). No internal features of the shells have been seen.

A group of shells including *Carbonicola crispa* separate clearly from the relatively longer and, in part, larger shells of the remainder (text-fig. 6). Amongst the latter, the strongly oblique growth of the smaller- and medium-sized shells, including *C. pontifex*, is striking. The resultant solid form of the valves, with a distinct hollow anterior to the arched carina (text-fig. 11A–G), renders the group readily distinguishable by eye from




TEXT-FIG. 6. Height plotted against length of shells of *Carbonicola* from Coalbrook, Tipperary, with comparative data added from Pennine and Welsh faunas.

*C. proxima* and allied variants (contrast, for instance, the umbones shown in text-fig. 11A–G with those of text-fig. 9G, H). Thus, with the exclusion of rare forms, the fauna falls naturally into three groups, associated with *C. crispa*, *C. proxima*, and *C. pontifex* respectively. Two of these may be roughly defined with respect to height and length of the shell by the fitted lines:

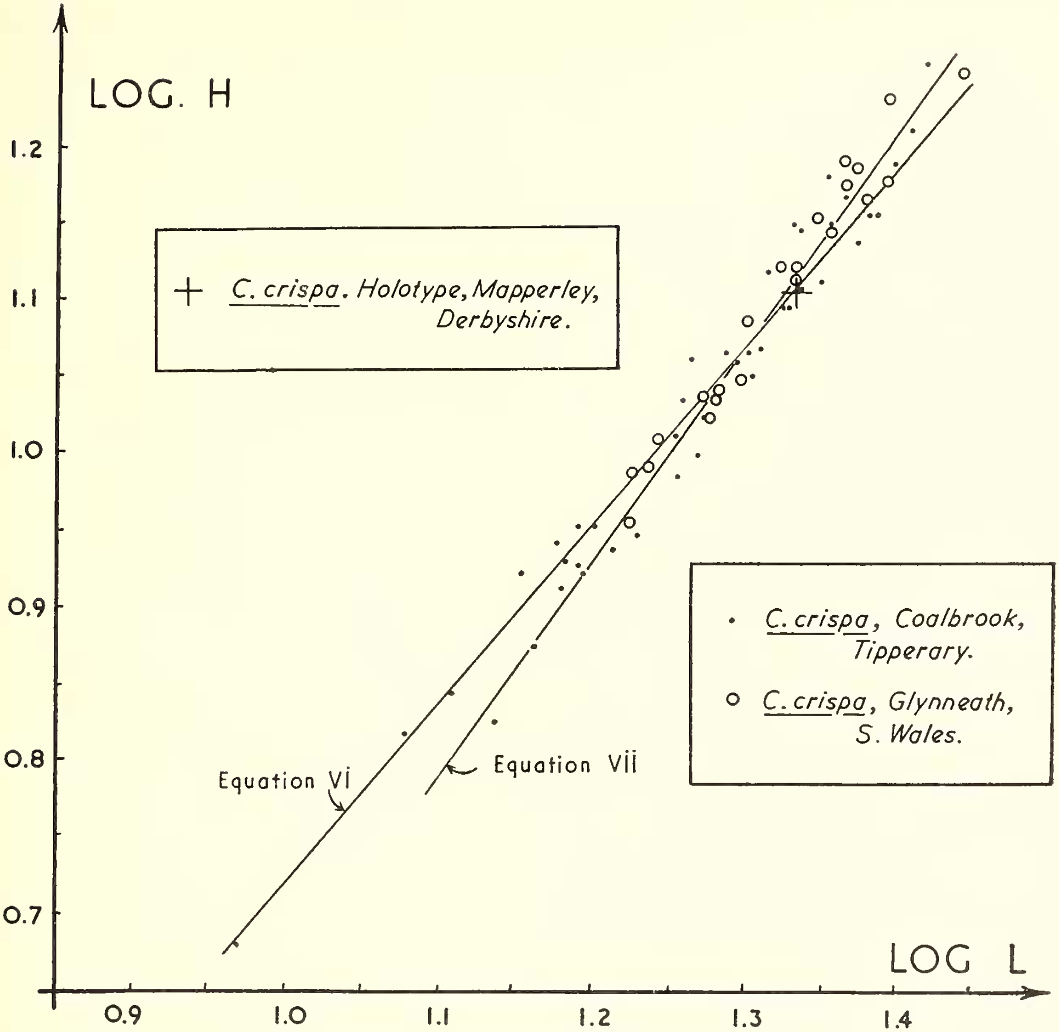
$$H = 0{\cdot}84\,L - 8{\cdot}67 \qquad \text{(iv)}$$

for the *C. proxima* group, and

$$H = 0{\cdot}62\,L - 2{\cdot}82 \qquad \text{(v)}$$

for the *C. pontifex* group.

These equations represent lines which are significantly different in slope and displacement. However, in view of the difficulty of measuring height and length when an appreciable amount of oblique growth has taken place in the shell, it might reasonably be contended that the figures on which equation (v) is based have a larger margin of error than those of the preceding lines. The writer would not deny this, but stresses that the separation of the *C. proxima* and *C. pontifex* groups is usually obvious by eye. In the




TEXT-FIG. 7. Logarithms of shell height and length in assemblages of *Carbonicola crispa* from Coalbrook, Tipperary, and Glynneath, South Wales.

Glynneath Band, where material is more abundant and better preserved, separation of these two groups has been effected by measuring the lengths and anterior ends of the shells (text-fig. 12).

The curved path of dots representing the height and length measurements of the *Carbonicola crispa* fauna straightens when logarithms of these values are plotted (text-fig. 7) to give a high coefficient of correlation, $r = 0{\cdot}977$. The fitted line for the *Carbonicola crispa* group then has the equation:

$$\log H = 1{\cdot}070 \log L - 0{\cdot}323 \qquad \text{(vi)}$$

From their distribution in the shale it appears likely that members of the three groups may at times have existed as members of a single community.

(*b*) *General character of the fauna.* As a whole the assemblage consists of relatively high forms, the mean H/L ratios of all three groups being over 50 per cent. (see Tables 2–4, and contrast those of *C. extenuata*, Table 1). Umbones are without inflation but vary in prominence. Ventral margins are typically with slight curvature and may be straight or reflected. Traces of a carinal swelling, or turn on the surface, are common in all three groups, and an appreciable carina, arched dorsally, may be present. Obesity appears to have been of a low order. In nearly all these features, most of which in combination have been noted as characterizing anthracosiid shells of relatively coarse-grained sediments (Eagar 1948, 1953*b*, pp. 161–3, 1961, p. 143), notably in the *lenisulcata* Zone, the whole assemblage contrasts with the *C. extenuata* faunas of Leinster and the Pennines. On the other hand the fauna shows striking similarity with the fauna of the Norton Musselband

TABLE 2

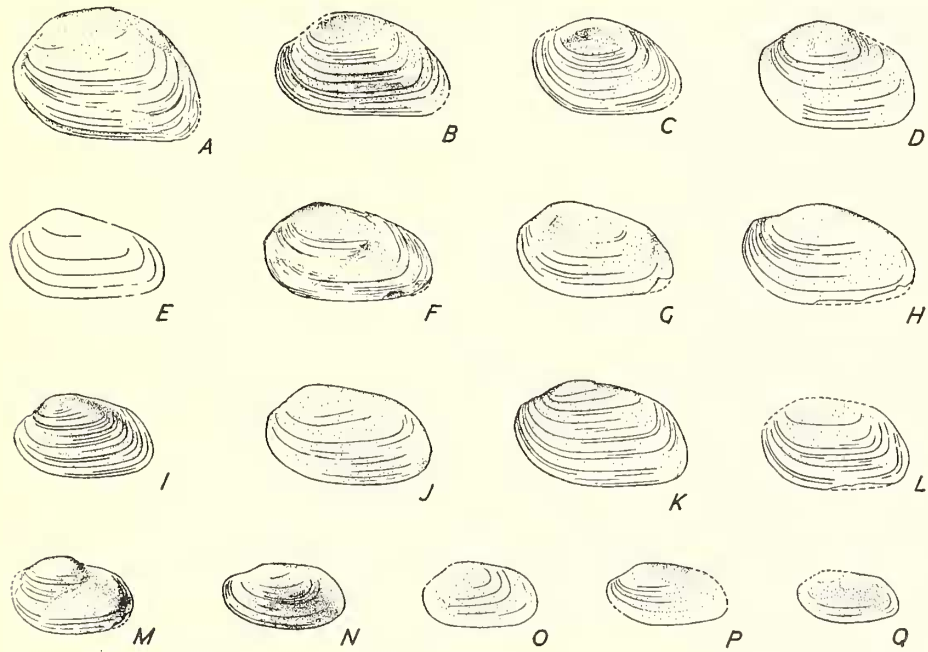
| | *Length in mm.* | | *H/L ratio %* | | *A/L ratio %* | |
|---|---|---|---|---|---|---|
| | *Range* | *Mean* | *Range* | *Mean* | *Range* | *Mean* |
| *C. crispa*, Coalbrook, Tipperary | 9·3–26·0 (42) | 18·61 | 48·9–70·0 (42) | 58·21 | 21·1–31·8 (21) | 25·98 |
| Bradford, Yorks. | 15·5–22·3 (11) | 18·72 | 45·5–61·0 (11) | 56·90 | 16·0–26·5 (7) | 20·80 |
| Holotype, Mapperley | 21·4 | | 60·0 | | 26·0 | |
| Cwm Gwrelech, Glynneath | 16·8–28·0 (22) | 21·14 | 55·5–69·4 (22) | 60·13 | 12·3–22·8 (17) | 19·20 |

Irish fauna of *Carbonicola crispa* compared with English and Welsh material. Measurements and tabular arrangement as for Table 1.

of the east Pennines which yields *Carbonicola crispa*, *C. proxima*, and occasional representatives of the *C. pontifex* group, as well as less common *C. extenuata*, and occurs in sediment of comparable grain size and character (Eagar 1956, p. 350). Considerable similarity is also apparent with the fauna of the *Carbonicola* band 28 feet below the Gnapiog Coal, towards the top of the *lenisulcata* Zone of the Coal Measures of Cwm Gwrelech, Glynneath, South Wales (Band $C_1$ of Leitch, Owen, and Jones 1958, p. 465), where again the groups of *C. crispa*, *C. proxima*, and *C. pontifex* are present (compare text-figs. 6 and 10, and see also Calver in Woodland and others 1957, p. 56). In the following sections the Coalbrook faunal groups are described with biometrical and other data bearing on corresponding faunas from the east Pennines and Glynneath.

(*c*) *Fauna of* Carbonicola crispa *Eagar.* Previous work on faunas of this species in the east Pennine coalfields, where little material has been available, has emphasized the high value of the height/length ratio of the shells and its rapid increase as growth proceeded. The Tipperary fauna of *C. crispa*, which is abundant, shows close dimensional similarity with the type faunas of Derbyshire and Yorkshire (Table 2, text-fig. 6), slightly larger forms being included in the Tipperary Band.

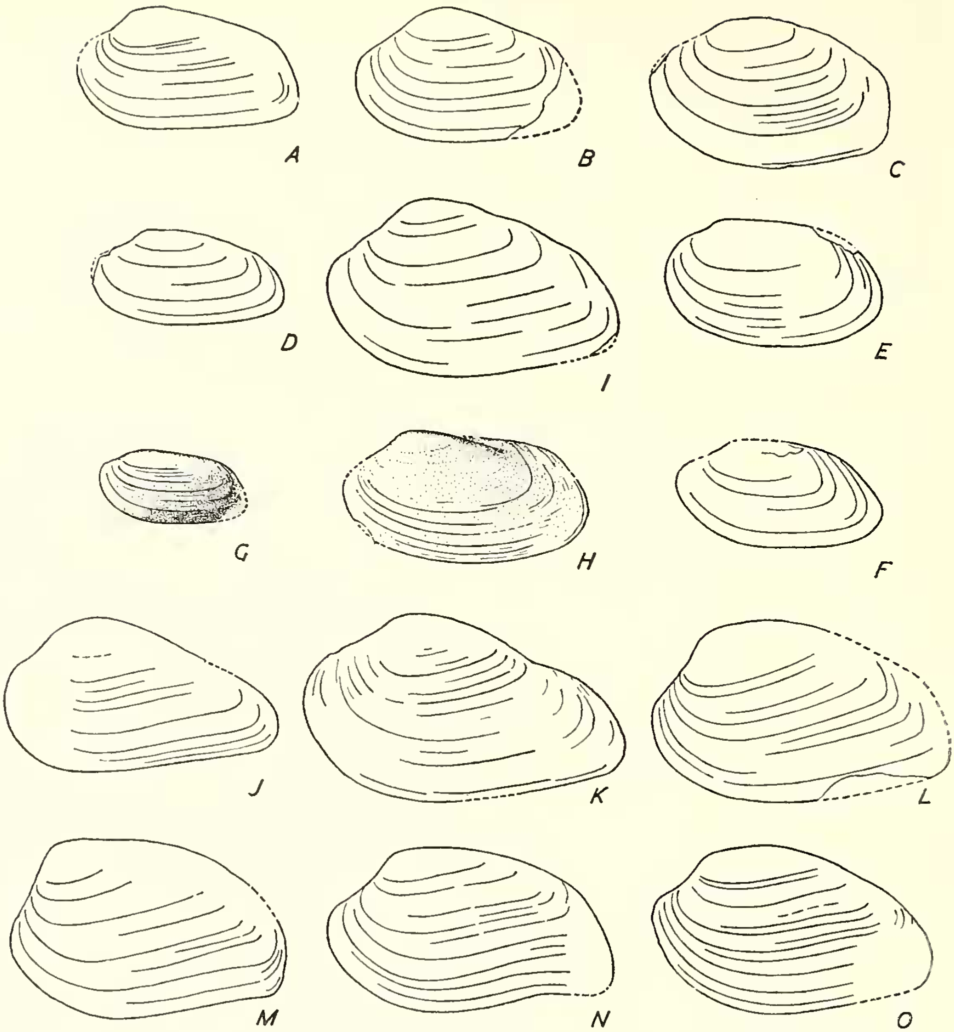
Obesities, as far as they can be measured, appear to have been of a low order, averaging perhaps about 25 per cent. in the three faunas. In Table 2 significant differences appear only in the higher A/L ratios of the Coalbrook shells by comparison with those of the Bradford and Glynneath faunas. Possibly some of the difference can be accounted for by the different modes of preservation found at Coalbrook on the one hand and the English and Welsh localities on the other. In the latter the shells are almost perfectly preserved so that the umbonal tip may be exactly located, whereas at Coalbrook shell thickness over the umbo may be reduced, or the shell imperfectly preserved, so that the length of the anterior end is easily overestimated.




TEXT-FIG. 8. Fauna of *Carbonicola crispa* Eagar from Coalbrook, Tipperary. F, G, *C. crispa*; B–D, H–M, O, *C.* aff. *crispa*; A, *C. sp.* (cf. *Anthracosia*); N, *C. sp.*; P, Q, *C.* cf. *fallax* Wright. M.M. LL2692–2703. E, outline of the holotype of *C. crispa*, from Mapperley. C, D–F reproduced as mirror images. Approximately natural size.

The sharp increase in height/length ratio with growth of shell is reflected throughout the somewhat limited range of variation shown by the Coalbrook specimens. The smallest forms tend to be comparable with the shorter variants of *Carbonicola fallax* (*sensu lato*) in shape, but are a little smaller (text-fig. 8P, Q). Increase in relative height with final loss of posterior truncation may be seen in the series of text-fig. 8F, G, H, D, C, B in order. A similar increase, with retention of the posterior superior angle, leads to rhomboidal outline (compare in order the shells of text-fig. 8G, H, I, J, K). A small degree of curvature of the ventral margin is typical, but the strong curvature shown in text-fig. 8N is rare, as is also the somewhat expanded posterior end seen in this shell.

Commonest are forms centred around text-fig. 8I, G, and D. Although the dimensions of the holotype of *Carbonicola crispa* are very near the mean dimensions of the Coalbrook fauna, the modal form of the latter, for instance text-fig. 8I, is less tapered to the posterior and has deeper truncation than the holotype. The same conclusions were reached regarding the modal form of the few specimens of *C. crispa* available from the east Pennine Coalfield (Eagar 1954, text-fig. 3).

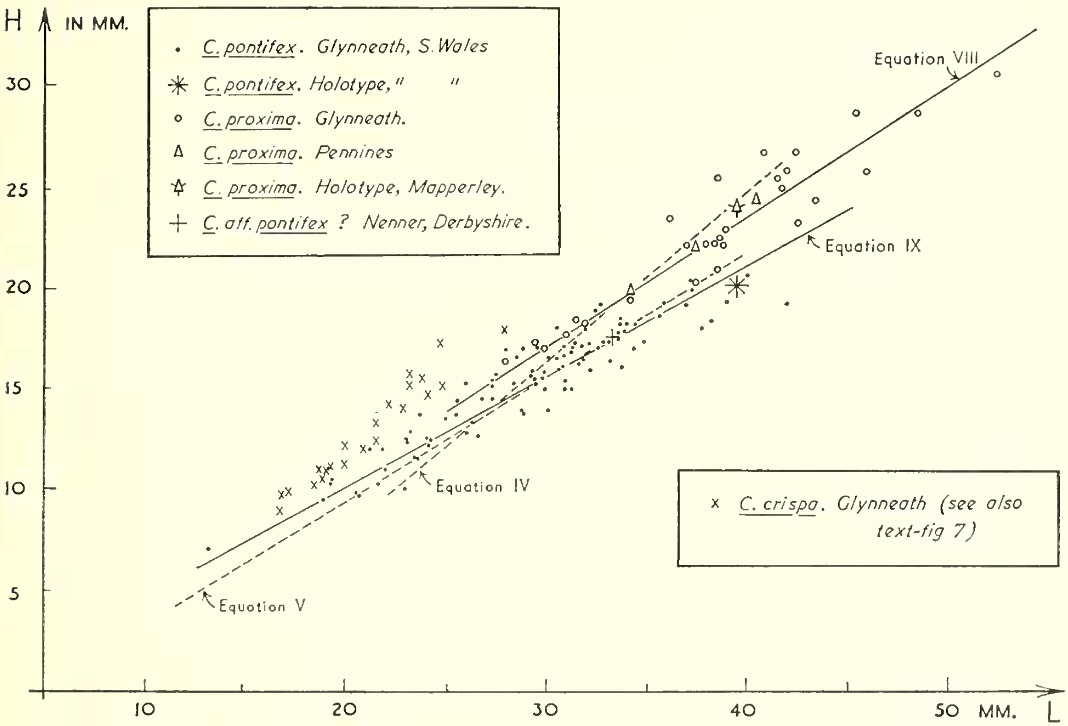



TEXT-FIG. 9. Fauna of *Carbonicola proxima* Eagar; A–H from Coalbrook, Tipperary; I, holotype, Mapperley; J–O, Cwm Gwrelech, Glynneath. B, *C. proxima*; A, C, D, K, L, O, *C.* aff. *proxima*; G, *C.* cf. *fallax* Wright; E. F. H, *C.* cf. *protea* Wright; J, *C.* cf. *pseudorobusta* Trueman; M, N, *C. sp.*; A–H, M.M. LL2698, 2704–9; J–O, M.M. LL2626A–2630A. C–F, J, R reproduced as mirror images. Approximately natural size.

The remarkable shell illustrated as text-fig. 8A recalls the outline of short variants of *Anthracosia* from the upper part of the *modiolaris* Zone (cf. Trueman and Weir 1951, pl. xv, fig. 19) and may also be compared with Eagar 1956, fig. 9*o*, and Jenkins 1960, text-fig. 4D, shells from near the base of the *communis* Zone. Although continuous variation between this form and undoubted members of the *C. crispa* group is not clearly demonstrable, it appears to the writer that the specimen is nearer to this group than any other and that it should be provisionally assigned to it.

The *Carbonicola crispa* fauna of Tipperary may be finally compared with that of

Glynneath, where separation from the *C. pontifex* group is less clearly marked, notably amongst the smallest shells (text-fig. 10), the two groups having some dimensional features in common. Although there is insufficient evidence at Glynneath for the unquestionable recognition of two distinct biospecies, on the basis of early umbonal growth and length of the anterior end, it is not unreasonable to separate the faunas, as has been




TEXT-FIG. 10. Height plotted against length of shells in an assemblage of *Carbonicola* from Cwm Gwrelech, Glynneath, with comparative data from the Pennines and Tipperary.

attempted in text-fig. 10, and to assume that the separation reflects at least a degree of genetic difference in the two groups. When logarithms of the heights and lengths of the supposed *C. crispa* group are plotted, the path of points straightens to give an increased coefficient of correlation ($r = 0{\cdot}975$) with a fitted line:

$$\log H = 1{\cdot}392 \log L - 0{\cdot}741 \qquad \text{(vii)}$$

for the Glynneath fauna (cf. equation (vi)).

Height and length measurements of the Tipperary and Glynneath shells, together with their fitted lines, are shown in text-fig. 7. It will be seen that although the slopes of equations (vi) and (vii) have proved significantly different at the 95 per cent. level, nevertheless above shell lengths of 16·5 mm. ($\log L \simeq 1{\cdot}2$ mm.) there is obviously no significant difference in the lengths and the heights of the shells and consequently in the fitted lines *over this range of length*. In short the significant difference between the slopes of equations (vi) and (vii) appears to have arisen as a result of the inclusion of smaller shells, with lengths between 9·3 and 16·4 mm., in the Tipperary fauna. If it be granted that the very close dimensional correspondence of the two faunas above the shell length of 16·5 mm. justifies the separation of *C. crispa* at Glynneath, then the evidence of text-fig. 7 strongly suggests that the logarithmic formula of equation (vi) does not adequately represent the line of mean growth of *C. crispa* over its full range at Tipperary. The logarithmic approach undoubtedly offers a better representation of this than does simple linear regression, but the logarithmic formula is evidently applicable to but a limited period of measurable growth, or is itself an incomplete expression of the total known range of growth in terms of height and length measurements. This conclusion is precisely that reached in investigating logarithmic formulae of the same pattern to represent the growth of *Carbonicola exporrecta* and associated fauna above the Sand Rock Mine of the topmost Namurian (Eagar 1952*b*, pp. 356–7).

(*d*) *Fauna of* Carbonicola proxima *Eagar*. It will be seen from text-figs. 6, 9, and 10 that most of the shells associated with *Carbonicola proxima* are smaller than their English and Welsh equivalents although in most other respects they show close similarity with them. Increase in height/length ratio of the shell with growth, clearly recognizable in the growth-lines of the holotype (Eagar 1956, fig. 10*a*), is given numerical expression in equation (iv) of text-fig. 6, where it will be seen that the holotype, paratype, and a topotype of this species fall along the extrapolation of the fitted line for the Tipperary specimens.

TABLE 3

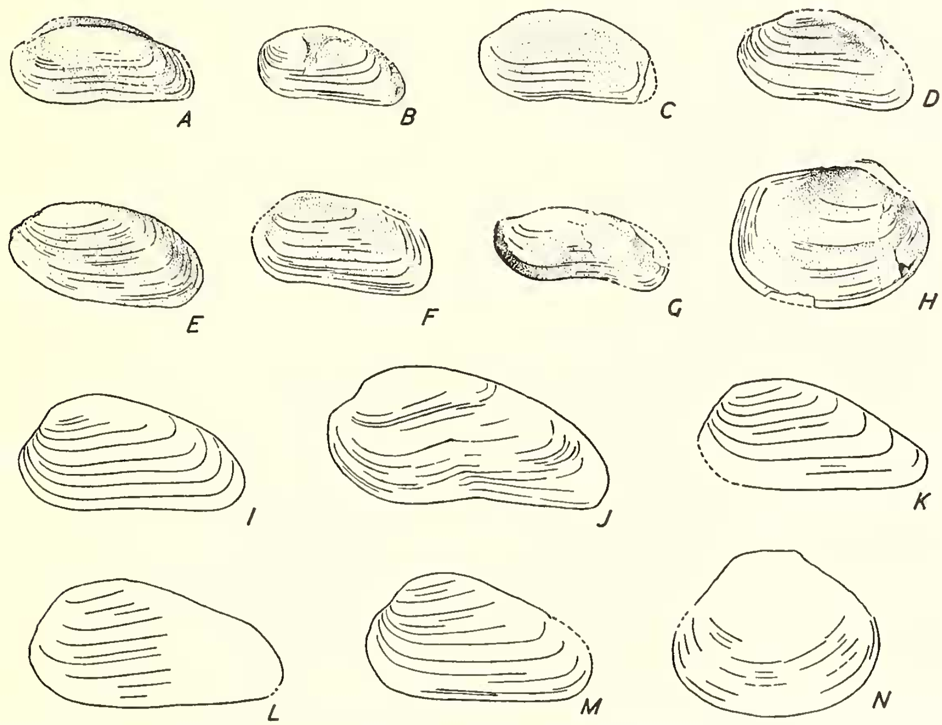
| | *Length in mm.* | | *H/L ratio %* | | *A/L ratio %* | |
|---|---|---|---|---|---|---|
| | *Range* | *Mean* | *Range* | *Mean* | *Range* | *Mean* |
| *C. proxima*, Coalbrook | 20·0–34·0 (25) | 28·31 | 42·3–65·4 (25) | 52·70 | 24·0–32·7 (8) | 28·17 |
| Cwm Gwrelech, Glynneath | 28·0–52·4 (28) | 38·65 | 54·5–66·0 (28) | 59·21 | 19·5–30·6 (26) | 24·70 |
| Holotype, Derbyshire | 39·5 | | 60·9 | | 25·5 | |

Irish fauna of *Carbonicola proxima* compared with Welsh and English material. Measurements and tabular arrangement as for Table 1.

The low value of the mean height/length ratio of the Coalbrook fauna by comparison with this ratio for the holotype is manifestly due to the smaller size of the Irish shells (see also text-fig. 13, where this point is demonstrated in a comparison of the Coalbrook and Glynneath faunas). On the other hand the slightly higher A/L ratios of the few measurable shells from Coalbrook may well to some extent reflect poor preservation of umbonal shell thickness at this locality with consequent overestimation of A, as appears possible in the case of *C. crispa*.

In text-fig. 9 the series G, D, and A shows shells with increasing H/L ratio and progressive prominence of the umbones. The series A, B, and C shows a continuation of this trend, on the assumption that the dorsal margin of the specimen figured as C has been raised slightly by lateral crushing, as has evidently happened, to a smaller degree, in the case of the holotype of *C. proxima* (text-fig. 9I). The remainder of the figured shells show rounding of the ventral margin to a varied extent with slight expansion in lateral outline towards the posterior part of the shell (text-fig. 9H, E) or increased posterior truncation with lowering of the umbo. Numerical strength, amongst a collection of thirty-five individuals, centres around the shell shown as text-fig. 9A and extends towards *C. proxima* (*sensu stricto*) (text-fig. 9B).

*Carbonicola* aff. *proxima* has already been recorded from near the top of the *lenisulcata* Zone in South Wales (Calver in Woodland and others 1957, p. 56). In the Glynneath fauna forms virtually identical with the type (e.g. text-fig. 9I) and to others recorded in Tipperary (e.g. text-fig. 9A, C, D, G, and F) grade with variants belonging to two trends




TEXT-FIG. 11. Faunas of *Carbonicola pontifex* sp. nov. A–G, Coalbrook, Tipperary, I–M, Cwm Gwrelech, Glynneath. H, I, *?Anthracosphaerium* sp. (cf. *C. discus* Eagar), Coalbrook and Cwm Gwrelech. B, J, *C. pontifex* (see also Plate 48, fig. 6); A, C, D, I, K, L, M, *C.* aff. *pontifex*; F, G, *C.* cf. *limax* Wright; E, *C. sp.* (cf. *Anthracosia ovum* Trueman and Weir). A–H, M.M. LL2710–17; I–N, M.M. LL2631A–2636A. C–F, I, J, M, mirror images. Approximately natural size.

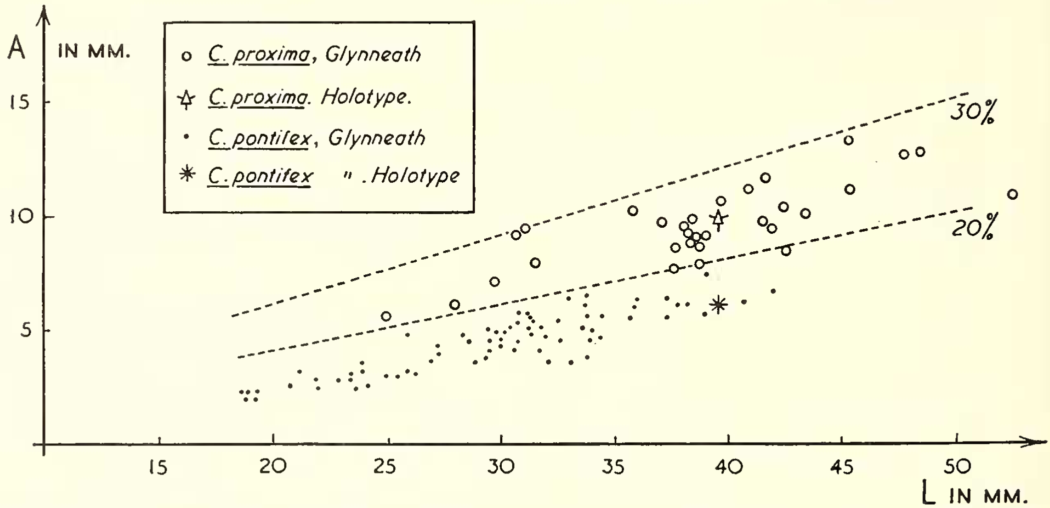
not previously recorded elsewhere. In the first of these, represented in order by the shells of text-fig. 9L, K, and Plate 48, fig. 12, the posterior end is progressively extended until, in text-fig. 9J, truncation is virtually lost and extreme variants are produced suggestive of the *C. communis* group. In the second trend, seen in the shells of text-fig. 9L, O, N, and M, and Plate 48, fig. 13, the shell is shortened and the ventral margin becomes straight or reflected as the dorsum arches with oblique growth. A few members of this trend thus show similarity to shorter variants of *Carbonicola pontifex* (e.g. text-fig. 11M) from which they appear to be separable dimensionally by their longer anterior ends (text-fig. 12) and more elevated umbones.

The Glynneath fauna differs from that of Tipperary in its greater size, in having less curvature of the ventral margin—for instance curvatures such as are illustrated in text-fig. 9H and E were not found—and in the possession of the two trends described above. In terms of shell height and length the Glynneath fauna is represented by the line:

$$H = 0{\cdot}654\ L - 2{\cdot}39 \qquad \text{(viii)}$$

with a coefficient of correlation $r = 0{\cdot}944$.

This line, drawn in text-fig. 10, is significantly less steep than the line for *C. proxima* from Coalbrook. That the difference in the slopes of equations (iv) and (viii) represents a real difference in the dimensional pattern of the faunas from the two localities may be




TEXT-FIG. 12. Length of anterior end (A) plotted against length of shell in faunas of *Carbonicola proxima* and *C. pontifex* from Cwm Gwrelech, Glynneath.

seen in text-fig. 13, where shell length has been plotted against the height/length ratio, with earlier growth stages added for a few shells from Glynneath. It will be seen that while much of the spread is the same for both faunas or that there is merely a difference in size (length), about one-quarter of the Glynneath shells—all large forms referable to the first of the new trends described above—lie outside the area of the Coalbrook shells. All, or nearly all of them, would have had relatively lower height/length ratios than any Coalbrook forms of comparable length over a considerable range of measurable growth.

(*e*) *Fauna of* Carbonicola pontifex *sp. nov.* The Coalbrook fauna of *C. pontifex* is characterized by relative elongation of shell, an appreciable degree of oblique growth and a resultant distinctive solid form. A carina, or carinal swelling, rises from the umbonal shoulders and passes backward, with dorsally convex crest, to die out in the posterior quarter of the shell. The dorsal convexity of the structure appears to be accentuated by lateral crushing (text-fig. 11C, D). Anterior to the carina, the shell is typically slightly hollowed and the ventral margin varies between straight, or nearly straight, and strongly reflected. In several cases the hollowed area is crossed obliquely near its centre by a shallow furrow which may terminate in an irregular notch or nick in the ventral margin, near its mid-point (text-fig. 11A, C).

Of the shells shown in text-fig. 11, which are representative of the range of variation, the mode centres around A, forms B, C, and D being common. Shells showing expansion to the posterior (F, G) are atypical, as is also text-fig. 11E.

The Glynneath shells, which are exceptionally well preserved (Plate 48, figs. 6–11, 14, 15, text-fig. 11I–M), display the distinctive solid form of the Coalbrook fauna and include several specimens in which the triangular hollow is crossed by a groove. Only a few of the smallest shells (Plate 48, fig. 10) are comparable with *Carbonicola limax*. Variation is wide, extending towards *C. crispa* (Plate 48, fig. 15) and to *C. proxima* (Plate 48, fig. 11), but the mode centres around the form of Plate 48, fig. 9 (text-fig. 11I) which is close to the mode of the Tipperary fauna.

In Table 4, and in the comparison of text-figs. 6 and 10, it will be seen that the Glyn-

TABLE 4

| | *Length in mm.* | | *H/L ratio %* | | *A/L ratio %* | |
|---|---|---|---|---|---|---|
| | *Range* | *Mean* | *Range* | *Mean* | *Range* | *Mean* |
| *C. pontifex*, Coalbrook | 17·6–26·3 (15) | 21·53 | 45·0–53·0 (15) | 48·61 | 15·4–24·0 (6) | 19·07 |
| *C. pontifex*, Glynneath | 13·1–41·9 (92) | 29·36 | 43·5–60·6 (92) | 52·66 | 10·3–23·2 (78) | 14·98 |

Dimensions of the holotype of *C. pontifex* are given in the systematic section. Arrangement as for Table 1.

neath fauna of *C. pontifex* grew to considerably larger size than the few measurable specimens from Coalbrook. Although the former fauna includes a few relatively short forms (e.g. text-fig. 11M, Plate 48, fig. 14) which have not been seen in the latter, the slightly greater mean H/L ratio of the Welsh fauna appears to be attributable merely to increased size (length), as might be expected from equation (v) for the Coalbrook shells. The fitted line for the Glynneath fauna is:

$$H = 0{\cdot}542\,L - 0{\cdot}48 \qquad \text{(ix)}$$

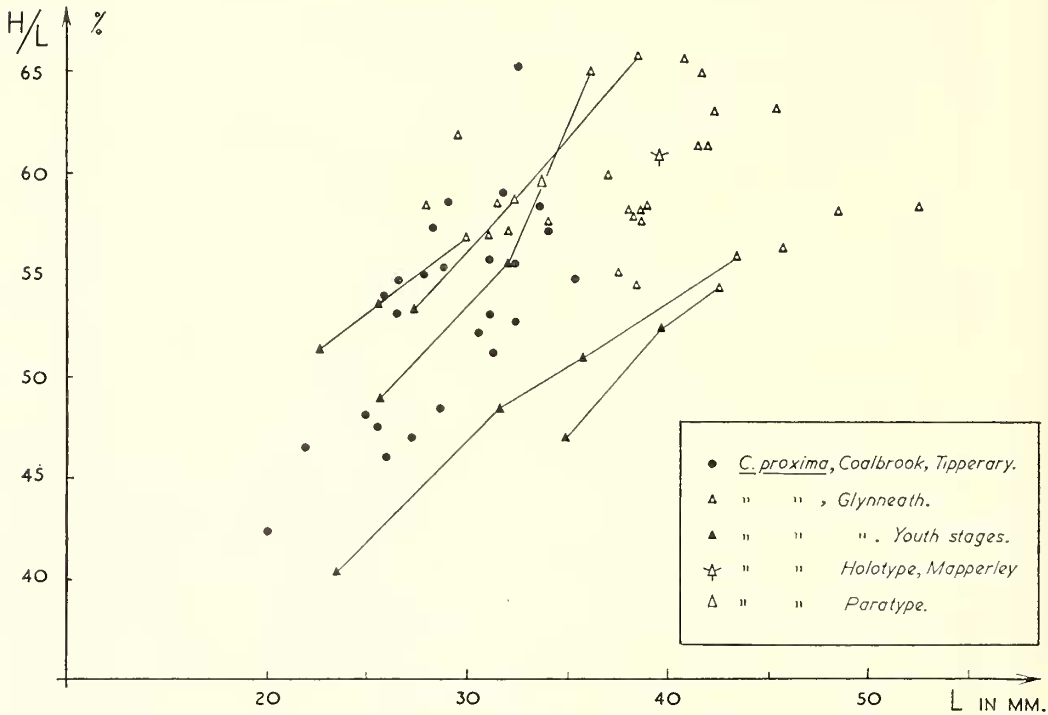
which is not significantly different in slope from the Coalbrook line (text-fig. 10, equation v).

*C. pontifex* (s.s.) has not been recorded from the east Pennines, but shells 15 feet below Tonge's Marine Band near Burnley show close similarity to this species. In text-fig. 11 and Eagar 1956, fig. 6 compare respectively B with *b*, C and D with *c*. In the Norton Musselband occasional shells, such as G.S.M. Bg. 793, from Mapperley, appear identical with Glynneath variants of the *C. pontifex* group having curved ventral margins (e.g. Plate 48, fig. 11). Several larger forms apparently in continuous variation with *C. proxima* (e.g. Eagar 1956, fig. 10*d*) also compare with this Glynneath shell.

(*f*) *Summary and stratigraphical conclusions.* (1) The *Carbonicola crispa* group is common to the Coalbrook Band of Tipperary, the Norton Musselband, and the Cwm Gwrelech ($C_1$) Band of Glynneath. The shells are a little larger in Glynneath than elsewhere, but in other respects show very close dimensional correspondence.

(2) The *C. proxima* group is also common to the three areas, being smallest in Tipperary and largest in Glynneath, where it shows trends suggesting linkage with *C. pontifex* sp. nov.

(3) The *C. pontifex* group is present in Tipperary and abundant at Glynneath where the shells are also larger and are sometimes difficult to separate from *C. proxima*. In the west Pennines, Burnley district, *C.* aff. *pontifex* is abundant near the top of the cyclothem which precedes that equivalent to the Norton cyclothem of the east Pennine area. In the latter the Norton Musselband has yielded occasional shells comparable with less




TEXT-FIG. 13. Height/length ratio plotted against length of shell in faunas of *Carbonicola proxima* from Glynneath, South Wales, and Coalbrook, Tipperary. The lines show the growth of five selected specimens.

common variants of *C. pontifex* at Glynneath, essentially forms which approach *C. proxima*.

(4) The *C. extenuata* group, well represented on a horizon near that of the Norton fauna at Bradford, Yorks. (Eagar 1956, p. 351), occurs in considerably less strength in the Norton Musselband of south Yorkshire and Derbyshire; it is evidently absent at Glynneath and Coalbrook.

(5) Rare discoidal shells, comparable in lateral outline with *Carbonicola discus* but possibly referable to *Anthracosphaerium sp.*, have been found in Tipperary and Glynneath.

The above evidence indicates that the Coalbrook Band should be placed near the top of the *lenisulcata* Zone and that its horizon is likely to be very near those of the Norton Musselband and the Glynneath ($C_1$) Band; probably it is a correlative of the latter.

## SYSTEMATIC DESCRIPTIONS

### Family ANTHRACOSIIDAE Amalitsky 1892

### Genus CARBONICOLA Trueman and Weir 1946

### *Carbonicola extima* sp. nov.

Plate 48, figs. 2, 3; text-fig. 3A, B

*Carbonicola sp.* Eagar 1956, pl. xxvi, fig. vii.

*Diagnosis.* Shell with length typically less than 20 mm. Lateral outline approximately in the form of an elongate ellipse, slightly flattened on the dorsal and ventral margins and with maximum depth at one-third to one-half of the length measured from the anterior end. Lobe of the anterior end high, the line of the anterior margin passing with rounded angle into the anterior umbonal slope, which is slightly re-entrant. Umbones are low, weakly defined and without inflation. The shell is gently and evenly swollen, being without trace of a carinal swelling or line of turn on its surface. Height/length ratio $< 42$ per cent. Anterior end $< 23$ per cent.

*Dimensions* (in mm.)

| | *Length* | *Height* | *Thickness* | *Anterior end* |
|---|---|---|---|---|
| Holotype. Plate 48, fig. 2; text-fig. 3B | 17·9 | 7·0 (39·1%) | 4·5 (25·0%) | 3·7 (20·6%) |
| Plate 48, fig. 3, *C. extima* | 18·9 | 7·7 (40·8%) | 5·0 (26·5%) | 3·5 (18·5%) |
| I.G.S. K212/7*, *C. extima* | 18·6 | 7·3 (39·2%) | 5·5 (30·0%) estimated | 4·2 (22·6%) |
| Text-fig. 3A and Eagar 1956, pl. xxvi, fig. vii, *C. extima* | 20·1 | 8·0 (39·5%) | 6·0 (30·0%) | 3·9 (19·5%) |
| I.G.S. K212/3C, *C.* aff. *extima* | 13·3 | 5·5 (41·3%) | 4·0 (30·0%) estimated | 3·0 (22·8%) |
| Text-fig. 3D, *C.* aff. *extima* | 18·8 | 8·1 (42·9%) | . . | 4·8 (25·5%) |

* I.G.S. Irish Geological Survey. See description of text-fig. 3.

*Further description and discussion of the type assemblage.* The holotype is associated with an assemblage of *Carbonicola extenuata* Eagar in Kilgorey Borehole (text-fig. 1) and with twenty smaller shells, of which thirteen are measurable (Table 5, below, text-figs. 2, 3B–E, G–K). No internal features of the shell are available. Comparison with material preserved in ironstone (Plate 48, fig. 3) suggests that both the holotype and several other small shells associated with it have suffered slight lateral compression with consequent reduction in the thickness/length ratio but with little, or no appreciable, modification in lateral outline. All the shells grouped with *C. extima* are gently and evenly swollen, none showing trace of a carina or turn on the dorso-lateral area.

Growth of shell in the holotype, as measured by successive growth-lines, evidently took place with slightly decreasing height/length ratio during the last 6 mm. of length. The same tendency may be observed in the small-shell group as a whole (text-fig. 3 and equation (ii); compare in order text-fig. 3J, G, I, E, and D).

The small-shell group of *C. extima* in the type assemblage shows limited variation linked with the pattern of growth. Thus short, oval forms are found mainly amongst the smallest specimens (text-fig. 3J, G, I). Slight decrease in the curvature of the ventral margin with increase in posterior taper is seen in the series of text-fig. 3K, D, C, the latter shell showing resemblance to small specimens of *C. extenuata*.

The small-shell group shares several features with the large-shell group of *C. extenuata* (compare as a whole text-fig. 3A–K with L to W) including solid form and occasionally near-identity of shape but not of size (compare, for instance, the shells of Plate 48, figs. 1 and

TABLE 5

| | *Length in mm.* | | *H/L ratio %* | | *T/L ratio %* | | *A/L ratio %* | |
|---|---|---|---|---|---|---|---|---|
| | *Range* | *Mean* | *Range* | *Mean* | *Range* | *Mean* | *Range* | *Mean* |
| Kilgorey | 8·6–19·3 (14) | 16·23 | 39·1–58·0 (14) | 45·05 | 25·0–30·0 (3) | 26·8 | 19·0–25·6 (8) | 22·78 |
| Swan | 18·9–20·0 (2) | 19·4 | 40·8–42·8 (2) | 41·8 | 26·5–30·0 (2) | 28·25 | 18·3–25·8 (2) | 22·05 |
| Bacup | 12·2–20·1 (2) | 16·1 | 39·5–50·0 (2) | 44·7 | .. | .. | 19·5–23·7 (2) | 21·60 |

Irish faunas of *Carbonicola extima* sp. nov. compared with two specimens from Bacup, Lancs. Measurements and tabular arrangement as for Table 1.

2). On the other hand the shells of the *Carbonicola extima* group in later stages of growth decreased in height/length ratio, whereas those of the *C. extenuata* group showed increase in this ratio (equations (ii) and (i) respectively). There seems, therefore, to be reasonable evidence for biospecific distinction between the two faunas, although they appear related and there can be no certainty that the small-shell group of *C. extima* does not include a few young specimens of *C. extenuata*. Nevertheless, the distinction between the two groups, based on a small sample, should be viewed with caution until confirmed by more material. Little is yet known about the pattern of relative growth in species of Anthracosiidae and indeed of recent marine and freshwater shells (Eagar 1953*b*, p. 159; Broadhurst 1959, fig. 4).

*Comparison. Carbonicola extima* is unlikely to be confused with any anthracosiid species other than variants of the *C. fallax* group from the top of the Namurian and the lower and middle parts of the *lenisulcata* Zone. Most of the latter are appreciably larger than *C. extima*, typically having greater relative height of shell or slightly more expansion to the posterior than characterizes this species (see, for example, Eagar 1947, fig. 1, 'west' arm of the variation diagram and its 'south-western' branch, fig. 14J, K, fig. 27*q*, shells which have also higher umbones). Moreover, although an occasional variant from faunas at or near the base of cyclothems in the Soft Bed–Bassy Mine succession may prove referable to, or comparable with, *C. extima*, the associated fauna, rich in larger *Anthraconaia*-like variants, will render the horizon of the fauna clear. The same considerations apply to the uncommon occurrence of variants similar to *C. extima* from the top of the Namurian (see, for example, Eagar 1953*a*, pl. xii, figs. 2K, 3J). Finally, shells comparable with *C. extima* from the lower *lenisulcata* Zone and the uppermost Namurian tend as often as not to lack the gentle swelling which characterizes the valves of this species, bearing instead, in the posterior third of the shell, an arched carina or line of urn on the surface of the shell (cf. Eagar 1947, fig. 8*b*).

*Distribution*. The type assemblage of *Carbonicola extima* came from Kilgorey Borehole (text-fig. 1) at 211 to 212 feet, a horizon 23 to 24 feet below the lower main seam of the Double Fireclays, Leinster Coalfield. On this horizon non-marine shells commence at 213 feet with members of the *C. extenuata* group only and faunas of *C. extima* mingled with *C. extenuata* are overlain by small *?Anthraconaia* cf. *bellula* (Bolton) at 210 feet. Elsewhere in the Leinster Coalfield shells are known from this horizon only at Garendenny Borehole, a mile to the north-west of Kilgorey (see Neville 1956, pl. iii) where the fauna is very similar and includes *C. extima*, at the village of Swan, and in the Aghamucky and Copley's Bridge Boreholes to the south-west (text-fig. 1) where only the overlying *?Anthraconaia* cf. *bellula* persists. Two shells which are comparable with *C. extima* and may be young individuals of *C. extenuata* were found in Ardra boring, half a mile south of Copley's Bridge, on a horizon estimated to be about 40 feet below that of Kilgorey. No other undoubted occurrences of *C. extima* are known in the Irish Coalfields.

In Britain, apart from its very rare occurrences in the measures from the topmost Namurian to the middle of the *lenisulcata* Zone, *C. extima* is known only from a single slab collected many years ago from about 70 feet above the Upper Mountain Mine and a short distance below Tonge's Marine Band, in the Bacup area of Lancashire (text-fig. 3A). This shell, which has already been figured and discussed (Eagar 1956, pp. 349–50), is associated with five other small shells, two of which are very similar to variants of *C. extima* from the type assemblage (compare respectively text-fig. 3F with G and I, and Eagar 1956, pl. xxvi, fig. vi with text-fig. 3D). The remaining shells on the slab include two small incomplete *Carbonicola*, which could be reconstructed as variants of *C. extima*, and a small *Naiadites* cf. *flexuosus* Dix and Trueman. The close similarity of the Leinster faunas of *C. extima* with the few specimens from Bacup district becomes more significant in the light of the similarity also of the *C. extenuata* faunas from these horizons. If the Kilgorey–Swan horizon is correlated with some part of the west Pennine cyclothem terminated by Tonge's Marine Band, then the faunas of *Carbonicola extima*, known only from Leinster and east Lancashire, have a much restricted stratigraphical range towards the base of the top quarter of the *lenisulcata* Zone.

### *Carbonicola pontifex* sp. nov.

Plate 48, figs. 6, 8; text-fig. 11J

*Diagnosis*. Shell asymmetrically subarcuate.The umbones are inclined forward over the lunule by oblique growth. In lateral view the dorsal slope is continuously curved to sweep backward, without posterior truncation, into the ventral margin, with which it forms a rounded angle. The ventral margin is strongly reflected, having its point of maximum embayment about midway along the length of the shell. Anterior lobe short and rather blunt. Lunule deep, but without sharp definition. Umbonal slope strongly re-entrant. Growth-lines near the umbo are inclined at more than 20° to the line of the ventral margin in the posterior half of the shell.

The surface of the shell is slightly hollowed over a triangular area, of which the base is formed by the greater part of the ventral margin and the apex extends towards the umbo. The point of maximum width lies at about half the height of the shell and at less than one-third of its length, measured from the anterior end. In dorsal view the shell is compressed towards the anterior end and gently tapered to the posterior. H/L 50–55 per cent. T/L about 35 per cent. A/L less than 17 per cent.

*Dimensions* (in mm.)

| | *Length* | *Height* | *Thickness* | *Anterior end* |
|---|---|---|---|---|
| Holotype. Plate 48, fig. 6; text-fig. 11J | 39·5 | 20·2 (51·0%) | 14·0 (35·5%) | 6·0 (15·2%) |
| *C. pontifex*. Plate 48, fig. 8 | 34·0 | 18·0 (52·9%) | .. | 5·0 (14·6%) |
| *C. pontifex*. M.M. Cw. 44C. Unfigured | 32·8 | 17·3 (52·6%) | .. | 4·5 (13·7%) |
| *C. pontifex*. M.M. Cw. 29. Unfigured | 30·6 | 16·5 (53·8%) | .. | 4·0 (13·0%) |
| *C.* aff. *pontifex*. Text-fig. 11L | 34·4 | 17·0 (49·4%) | 10·0 (29·0%) | 4·5 (13·1%) |
| *C.* aff. *pontifex*. Plate 48, fig. 9 | 29·5 | 15·4 (52·0%) | 10·5 (35·0%) | 5·0 (17·0%) |
| *C.* aff. *pontifex*. Plate 48, fig. 14 | 25·5 | 13·7 (53·5%) | 8·0 (31·0%) | 3·0 (11·8%) |
| *C.* aff. *pontifex*. Eagar 1956, fig. 6*b* | 25·8 | 12·7 (49·2%) | .. | 3·2 (12·5%) estimated |

*Remarks and further description.* The specific name refers to the subarcuate lateral outline of *C. pontifex*, the shape 'making a bridge', the first meaning of the Latin.

The holotype is an unusually large individual and displays well the relative tumidity of the valves beneath and immediately posterior to the umbo. In the centre of the right valve the triangular depression is crossed obliquely by a shallow groove, the path of which is marked by notches in the growth-lines and in the ventral margin. The groove is also found on one valve, left or right, of a few other individuals in the types assemblage (see also Plate 48, fig. 13). It is presumed to be a minor malformation of shell to which members of the *C. pontifex* group were particularly prone. Comparable cases are known in recent Unionidae, for example in *Lampsilis patulus* (Lea) from Kentucky (Manchester Museum E2012, Coll. R.D. Darbishire) where again the groove is either on the left or the right valve of one individual.

*Comparison. Carbonicola pontifex* differs from *C. limax* in lacking the posterior expansion of this species, in having greater H/L ratio and shorter anterior end. In lateral view *C. pontifex* shows superficial resemblance to elongate variants of *Anthracosia phrygiana* (Wright) but differs from these in dorsal view, showing a bulge immediately posterior to the umbo, posterior to which the shell tapers gently, as is typical of *Carbonicola* (contrast the subparallel sides of *Anthracosia* in Trueman and Weir 1952, pl. xx, fig. 5).

*Distribution.* The type fauna of *C. pontifex*, from Cwm Gwrelech, Glynneath, is mingled with faunas of *C. proxima* and *C. crispa* 29 feet below the Cnapiog Coal and near the top of the *lenisulcata* Zone. Similar faunas occur in comparable positions at Cwmgiedd, Ystalyfera (Trueman and Ware 1932, p. 7), in the Dulais Valley Borehole No. 2 (G.S.M. Bi6110 represents the species *sensu lato*), and at Margam Park No. 2 Borehole, where there is also a second horizon, 50 feet lower, on which some very small shells appear referable to the *C. pontifex* group (Woodland and others 1957, p. 49). In the Tipperary Coalfield *C. pontifex* occurs in the Coalbrook Band, probably on the same horizon as the type locality. In the Pennine Coalfields *C.* aff. *pontifex* is occasionally found in the Norton Musselband. Forms nearer the type occur in more abundance on a slightly lower horizon in the Burnley district. Finally, above the Lower Foot Mine there occur rarely short variants of *C. limax* (Eagar 1947, pl. 1, fig. v) which approach the shape but not the size of *C. pontifex*.

Family MYALINIDAE Frech 1891, emend. Newell 1942

Genus *Anthraconaia* Trueman & Weir 1946

*Anthraconaia fugax* sp. nov.

Plate 47, figs. 7, 10, 11, 14

*Anthracomya wardi* Hind 1893, pl. ix, fig. 10.
*Anthracomya wardi* Hind 1895, pl. xv, figs. 13, 19.
*Anthracomya wardi* Bolton 1895, pl. ii, fig. 16.

A new name has long been required for the group of medium-sized, elongate, laterally flattened *Anthraconaia* first described by Hind (1893, 1895) from the Burnley Coalfield and now in the Manchester Museum. As is clear from Wild (1886, p. 184), Hodson (1945, p. 362), and Jackson (1952, pp. 60–61) all the material has almost certainly come from above the Low Bottom Bed, Fulledge (see also Wright 1938, p. 18). Hind referred a number of well-preserved shells to *Anthracomya wardi* Salter, a species based on a poorly preserved holotype from near the top of the *modiolaris* Zone of the North Staffordshire Coalfield. The Burnley shells all differ from *A. wardi* Salter in having much lower height/length ratio and from better-preserved *Anthraconaia* from near the top of the *modiolaris* Zone, and from higher horizons, usually in this feature and in others to be described below. The Burnley group was recognized, but not named, by Wright (1938, p. 17, figs. 3*a–c*) among shells from a lower horizon in the *communis* Zone of Rochdale. Comparable material has subsequently been found as occasional specimens in the *communis* and upper *lenisulcata* Zones of other coalfields.

*Diagnosis.* Shell elongate, with small, flattened, inconspicuous umbones which, in internal moulds, are closely spaced but not contiguous. In lateral view the umbones barely rise above the line of the median ridge. Anterior lobe of shell high, forming roughly a half-ellipse, the lines of growth sweeping forward from the ventral margin with increasing curvature to turn, with rounded angle of about 90°, into the gently re-entrant anterior umbonal slope. For two-thirds of the length of the shell, measured from the anterior end, the ventral margin is almost straight, making an angle of about 5° with the hinge-line. Sides of the shell are flattened anterior to an oblique carinal swelling which rises behind the umbo and extends with nearly straight line of crest almost to the posterior ventral angle. The sides of the shell and internal mould are parallel in dorsal view, being tapered in the anterior third of the length and in the posterior quarter of it. H/L ratio 34–39 per cent. A/L ratio 20–24 per cent. T/L ratio $< 25$ per cent.

*Dimensions* (in mm.)

| | *Length* | *Height* | *Thickness* | *Anterior end* | $\beta$ | $\alpha$ | $\gamma$ |
|---|---|---|---|---|---|---|---|
| *A. fugax*, holotype, Plate 47, fig. 14 | 27·7 | 10·3 (37·2%) | 5·5 (19·8) | 6·0 (21·7%) | 125° | 18° | 37° |
| *A. fugax*, Plate 47, fig. 7 | 43·0 | 16·0 (37·1%) | .. | 9·5 (22·0%) | 128° | .. | 34° |
| *A. fugax*, Plate 47, fig. 11 | 32·8 | 12·0 (36·6%) | 7·0 (21·3%) | 6·7 (20·5%) | 120° | 22° | 35° |
| *A. fugax*, Plate 47, fig. 10 | 29·2 | 10·2 (34·8%) | 6·0 (20·5%) estimated | 6·4 (21·9%) | 125° | 15° | 32° |
| *A.* aff. *fugax*, Plate 47, fig. 15 | 31·5 | 10·9 (34·5%) | .. | 7·3 (23·0%) | 115° | 23° | 35° |
| *A.* aff. *fugax*, Plate 47, fig. 5 | 24·0 | 9·6 (40·0%) | 4·9 (20·5%) | 4·8 (20·0%) | 110° | 25° | 34° |
| *A.* aff. *fugax*, Plate 47, fig. 13 | 19·5 | 7·7 (39·5%) | 3·5 (18·0%) | 4·4 (22·5%) | 115° | 28° | 80° |
| *A.* cf. *fugax*, Plate 47, fig. 6 | 27·5 | 10·3 (36·8%) | .. | 5·8 (21·0%) | 110° | 15° | 32° |
| *A. sp.*, Plate 47, fig. 9 | 24·9 | 11·5 (46·1%) | 7·3 (29·0%) | 4·5 (18·0%) | 135° | 23° | 41° |

$\alpha$, $\beta$, and $\gamma$ measured as in Trueman and Weir 1957, p. 212, text-fig. 29.

*Further description and discussion.* The figured specimens of Hind (1895, pl. xv, figs. 13, 16–19) have been rejected as type material in favour of the Manchester Museum mould W603 (Plate 47, fig. 14) which shows best the diagnostic solid form of the species and has slightly better documentation than Hind's best specimen (Plate 47, fig. 11). Both these shells show impressions of the ligament which in the holotype extends backward 8 mm. from the umbo. The dorsal margin of the holotype is straight and almost com-

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PLATE 47

Magnifications are stated on the plate.

Fig. 1*a–c*. *Anthraconaia fabaformis* (Kinahan) G.S.M. 5101. Bilboa Colliery, Leinster (Castlecomer) Coalfield. Roof of Ward's Seam, *lenisulcata* Zone. Figured as *Anthracomya subcentralis* Salter by Hind 1895, pl. xvii, fig. 3 and erroneously referred to the roof of the Four Foot Coal (Eagar in Nevill 1956, p. 13).

Fig. 2*a*, *b*. *Anthraconaia* aff. *fabaeformis* (Kinahan) M.M. LL2718 E Coll. R. M. C. Eagar. As for fig. 1.

Fig. 3. *Anthraconaia* aff. *fabaeformis* (Kinahan) T.C. 49.1.7/2. Old tip 625 yds. S. 23° E. of trigonometrical station at 988 feet marking the summit of Bregawn Hill, Slieveardagh Coalfield, Co. Tipperary. Above the Upper Glengoole Coal, upper *lenisulcata* Zone.

Fig. 4. *Anthraconaia* aff. *fabaeformis* (Kinahan) T.C. 49.1.7/4. As for fig. 3. Much enlarged view of the articular region of the internal mould.

Fig. 5. *Anthraconaia* aff. *fugax* sp. nov. M.M. L2069d. E Coll. Kay-Shuttleworth. Burnley Coalfield, *communis* Zone. Probably from above the Low Bottom Bed, Fulledge.

Fig. 6. *Anthraconaia* cf. *fugax* sp. nov. I.G.S. CB442. From 442 feet, Copley's Bridge Borehole, 30 yds. WSW. of Copley's Bridge, 2 miles NNE. of Castlecomer, Leinster Coalfield. 104 feet above Ward's Seam, *lenisulcata* Zone.

Fig. 7. *Anthraconaia fugax* sp. nov. M.M. L2089a. E Coll. Kay-Shuttleworth. Fulledge Colliery, Burnley. From bastard cannel overlying the Low Bottom Bed, *communis* Zone. Figured as *Anthracomya wardi* Salter by Hind 1893, pl. ix, fig. 10; 1895, pl. xv, fig. 13; and by Bolton 1895, pl. ii, fig. 16.

Fig. 8. *Anthraconaia* aff. *fugax* sp. nov. M.M. L8201A. E Coll. W. A. Parker. Sparth Bottoms, Rochdale. About 180 feet above the Arley Mine, *communis* Zone. Figured W. B. Wright 1938, fig. 3*b*, as *Anthracomya sp.*

Fig. 9. *Anthraconaia sp.* possibly a variant of the *A. fugax* group. M.M. L2072. E Coll. Kay-Shuttleworth. As for fig. 5.

Fig. 10. *Anthraconaia fugax* sp. nov. M.M. L8201b. As for fig. 8. Figured as *Anthracomya sp.* by W. B. Wright 1938, p. 18, fig. 3*a*.

Fig. 11. *Anthraconaia fugax* sp. nov. M.M. L2069b. E Coll. Kay-Shuttleworth. As for fig. 5. Figured as *Anthracomya wardi* by Hind 1895, pl. xv, fig. 19.

Fig. 12. *Anthraconaia* aff. *fugax* sp. nov. M.M. L7103A. Coll. W. H. Sutcliffe. As for fig. 8.

Fig. 13. *Anthraconaia* aff. *fugax* sp. nov. Young form. M.M. L2069c. E Coll. Kay-Shuttleworth. As for fig. 5. Figured as *Anthracomya wardi* by Hind 1895, pl. xv, fig. 17.

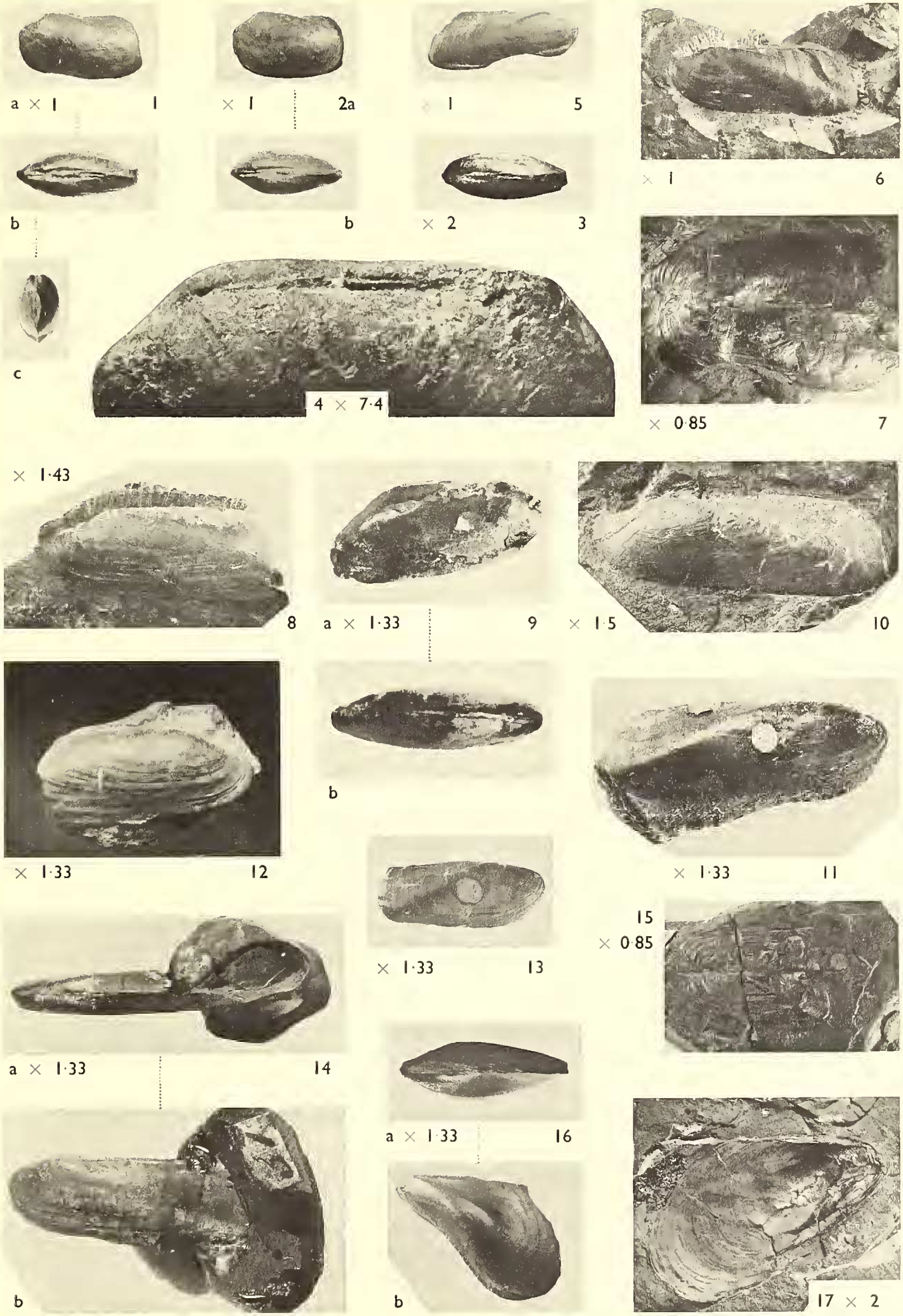
Fig. 14. *Anthraconaia fugax* sp. nov., holotype. M.M. W603. E Coll. G. Wild. Fulledge Colliery, Burnley. Assumed to be from above the Low Bottom Bed, *communis* Zone.

Fig. 15. *Anthraconaia* aff. *fugax* sp. nov. M.M. W602. E Coll. G. Wild. Fulledge Colliery, Burnley at a depth of 153 yds. (above the Low Bottom Bed). Figured as *Anthracomya wardi* Salter by Hind 1895, pl. xv, fig. 18.

Fig. 16. *Naiadites hibernicus* sp. nov., holotype, dorsal and lateral views. I.G.S. Agh536/WH53. From 536 feet, Aghamucky Borehole, ¼ mile ESE. of Drumgoole Bridge and ¾ mile E. of Castlecomer. 34 feet below the horizon of the *Gastrioceras subcrenatum* Marine Band. See also text-fig. 14A.

Fig. 17. *Naiadites* aff. *hibernicus* sp. nov. T.C. CK36/1E. Killeshin Glen, Leinster (Castlecomer) Coalfield (Nevill 1956, pl. ii, Loc. S. 5). Immediately below the *Gastrioceras cumbriense* Marine Band. See also text-fig. 14C.

G.S.M. Geological Survey Museum; M.M. Manchester Museum; I.G.S. Irish Geological Survey Collections, Dublin; T.C. Trinity College School of Geology Collections, Dublin.




EAGAR, Non-marine lamellibranchs

plete, the hinge junction forming a knife edge in the posterior half of the shell. In Hind's specimen (fig. 11) the dorsal margin is broken in the posterior half of the shell. What remains of the hinge-line anterior to this shows very slight dorsally convex curvature, so that it is possible that the dorsal margin may have been arcuate in the posterior half of the shell (see Plate 47, fig. 10).

In the holotype the anterior end is worn round the margins of the mould so that the outline of the shell has been blunted and the line of the re-entrant anterior slope (see fig. 5) has been lost. The anterior end of the right valve of the type specimen has been slightly displaced dorsally with respect to the left valve, with the result that the lunular area is not clear; but there is a strong suggestion that the mould had a very narrow, shallow lunule, sharply defined by the anterior umbonal shoulders, as is seen in the specimen of fig. 5.

The carinal swelling in the holotype and other solid specimens from Burnley has a broadly rounded crest which reaches its maximum definition in the posterior third of the shell. Anterior and ventral to the swelling the shell is flattened and may be slightly hollowed towards the ventral margin. As noted by Hind, over this area the lines of growth are well marked. Over the crest of the swelling and on the compressed area between the crest and the dorsal margin the shell is almost smooth. This area is crossed, however, by one or more faint radial ridges, flanked by equally faint grooves, all lying within the angle formed between the line of crest of the carinal swelling and the hinge-line. The structures, which may have strengthened the shell in its weakest, 'knife-edged' part, can be seen easily in the specimens of Plate 47, figs. 11 and 13, and appear also in crushed specimens (figs. 7, 15). The radiating ridges vary considerably in definition, being discernible in the holotype and some other specimens only in certain lights.

The relatively smooth post-carinal areas of *A. fugax* are also crossed by faint corrugations marking lines of growth (Plate 47, figs. 5, 11, 13, 14) or by growth-lines which are finer than elsewhere on the shell (figs. 7, 15). In the case of the first four specimens referred to, the corrugations indicate that during the final and greater part of the life of the lamellibranch the posterior margin of the shell grew with gentle curvature in continuity with the sharper curve of the posterior ventral angle and without change in shape. In the largest known specimen of the group (fig. 7) the dorsal half of the posterior margin became less curved and almost straight during the latter stages of growth, approximately the last 10 mm. of increase in shell length. In the small specimen (fig. 15) the posterior margin became straight in its dorsal half at a length of about 20 mm. The shell subsequently developed an incipient auricle and auricular sinus. A slightly stronger auricle is developed in a poor *Anthraconaia* aff. *fugax* of doubtful documentation in the Manchester Museum Kay-Shuttleworth Collection (figured by Hind 1895, pl. xv, fig. 16).

Very little other developmental change in shape can be observed from the growth-lines of the Burnley fauna. Smaller specimens, for example that of Plate 47, fig. 13, may appear to be less expanded to the posterior than larger ones, but it seems very likely that this shell would have achieved the typical outline of *Anthraconaia fugax*, had the life of its owner been longer, not by increased postero-ventral growth but by the dorsal 'upward' growth of the hinge margin as the ligament gradually extended back from the umbo.

A 'downward' flexure of the posterior part of the dorsal margin was apparently not uncommon in the group. Cleaning of the shells from Sparth Bottoms, Rochdale (Plate 47, figs. 8, 10, 12), has revealed subarcuate dorsal margins (contrast Wright 1938, figs.

3*a*, *b*). In two cases the anterior lobes are lower than in any specimens seen by the writer from Burnley.

The shell of Plate 47, fig. 9 differs obviously from the remainder of the Burnley material. Although considerably more obese than *A. fugax* and with more widely spaced umbones, the shell in dorsal view shows an approach to the characteristic profile of the group and may possibly prove to be a related form.

*Comparison. Anthraconaia fugax* appears comparable only with *? Carbonicola lenisulcata* (Trueman), a species which shows both internal and external features suggestive of this genus, into which it appears to grade (Eagar 1947, 1953*a*). Although the internal features of *A. fugax* are unknown, externally the species appears typical of the genus *Anthraconaia*, the shell substance being thinner than that of *? C. lenisulcata*; it has finer growth-lines, a narrower hinge-plate, as suggested by partial internal moulds, and more closely spaced, narrower umbones, which tend to rise just above the median ridge of the internal mould (whereas in *? C. lenisulcata* they do not). The internal mould of *A. fugax*, moreover, has a narrow sharply defined lunule, whereas in *? C. lenisulcata* the lunular area is wide and without sharp definition. In *Anthraconaia fugax* the angle $\beta$ is not much more than 125° and may be appreciably less, whereas in *? C. lenisulcata* this angle is very large, about 140°. Finally, although both species show some variation in the form of the

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PLATE 48

Figures natural size, unless otherwise stated.

Fig. 1. *Carbonicola extenuata* Eagar M.M. LL2685A. E Coll. R. M. C. Eagar. Stream section 900 yds NW. of cross-roads at Swan settlement, 6 miles NNE. of Castlecomer, Leinster Coalfield. About 150 feet above Ward's Seam, *lenisulcata* Zone.

Fig. 2. *Carbonicola extima* sp. nov., holotype. I.G.S. K212/4A. From 212 feet, Kilgorey Borehole, immediately south of road, 1,130 feet W. of junction of Kilgorey, Crettyard, and Garendenny roads, 7½ miles W. of Carlow, Leinster Coalfield. 46 feet below top of upper seam of Double Fireclays. See also text-fig. 3B. ×2.

Fig. 3. *Carbonicola extima* sp. nov. T.C. CS/II/1F. As for fig. 1.

Fig. 4. *Carbonicola* aff. *extenuata* Eagar. I.G.S. K211/1E. From 211 feet, Kilgorey Borehole (see fig. 2). See also text-fig. 3W.

Fig. 5. *Carbonicola* aff. *extenuata* Eagar. M.M. LL2719. From immediately above the Lower Mountain Mine, Victoria Pit, N.C.B., Standish, near Wigan.

Fig. 6. *Carbonicola pontifex* sp. nov., holotype. M.M. LL2632. E. Coll. D. G. Jones. From the bank of Cwm Gwrelech, Pont Walby, Glynneath, Glamorgan. From *c.* 30 feet below the base of the Gnapiog Coal (Leitch, Owen and Jones 1958, p. 464, fig. 2, $C_1$). See also text-fig. 11J.

Fig. 7. *Carbonicola pontifex* sp. nov., M.M. LL2629A. As for fig. 6.

Fig. 8. *Carbonicola pontifex* sp. nov., showing lateral crushing. M.M. LL2637. As for fig. 6.

Fig. 9. *Carbonicola* aff. *pontifex* sp. nov. M.M. LL2631A. As for fig. 6. See also text-fig. 11I.

Fig. 10. *Carbonicola* cf. *limax* Wright. Young shell in the *C. pontifex* assemblage. M.M. LL2638A.

Fig. 11. *Carbonicola sp.*, *C. pontifex* group, showing trend towards the outline of *C. proxima*. M.M. LL2639. As for fig. 6.

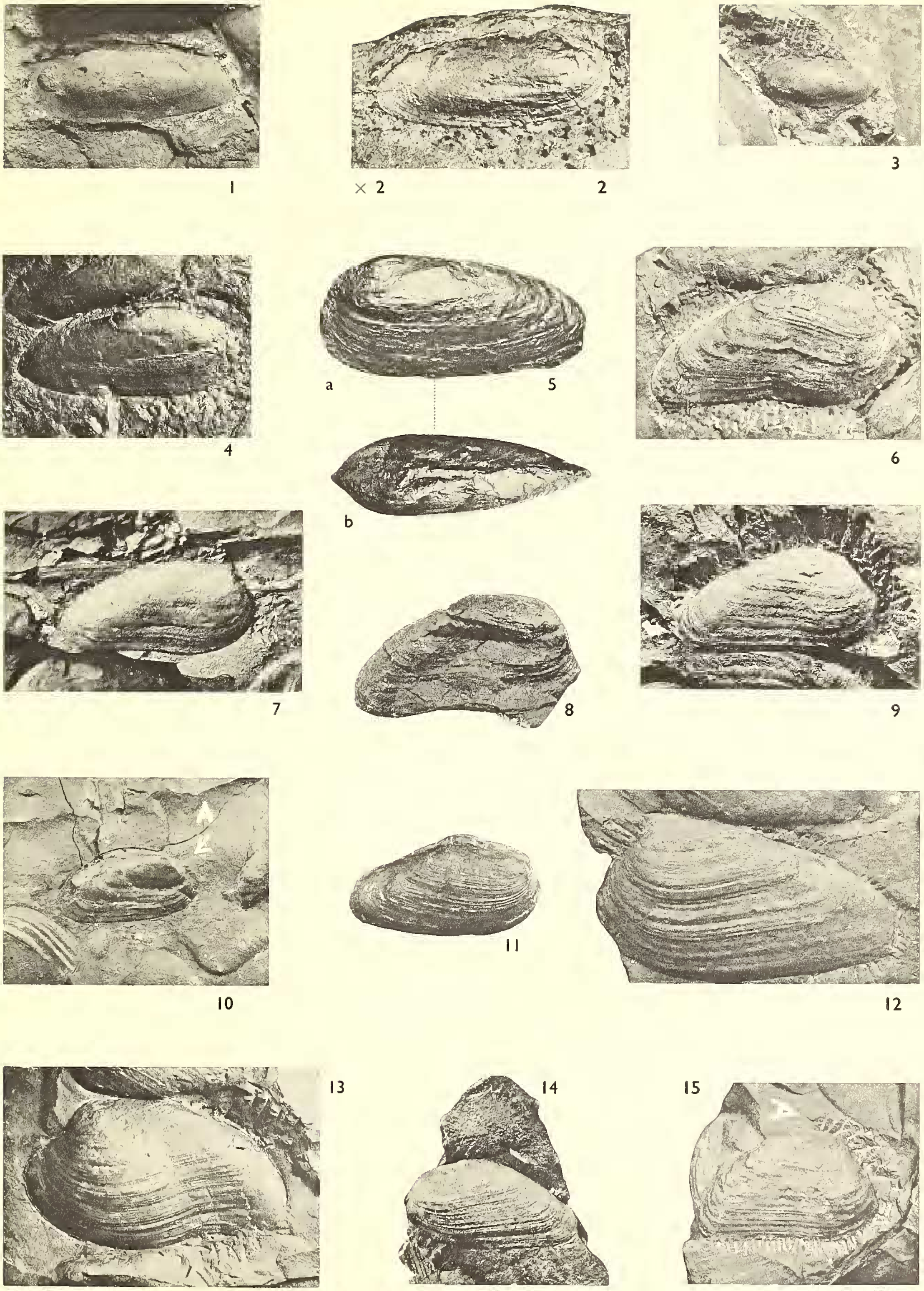
Fig. 12. *Carbonicola* aff. *proxima* Eagar. M.M. LL2640. As for fig. 6.

Fig. 13. *Carbonicola sp.* (*C. proxima* group) showing deep hollowing with irregular furrows anterior to the carina. M.M. LL2630A. As for fig. 6. See also text-fig. 9M.

Fig. 14. *Carbonicola* aff. *pontifex* (cf. *Anthracosia phrygiana* (Wright)). M.M. LL2641. As for fig. 6.

Fig. 15. *Carbonicola sp.*, a variant of the *C. pontifex* group showing approach towards the outline *C. crispa* Eagar. M.M. LL2642A. As for fig. 6.

Initials denote collections, as for Plate 47.



EAGAR, Non-marine lamellibranchs

anterior lobe and of the oblique carinal swelling, in *A. fugax* the lobe tends to be high and to take the form of a semi-ellipse, whereas in *?C. lenisulcata* it is lower and nearer the shape of a semicircle; the carinal swelling is a slightly stronger feature in *A. fugax*, tending to be straight and to persist further towards the ventral angle than in *?C. lenisulcata*, so that in dorsal view *?C. lenisulcata* lacks the long subparallel sides of *A. fugax*.

*Distribution*. *Anthraconaia fugax* has been found in the upper part of the *communis* Zone of the Burnley Coalfield, the described material all coming, probably, from the Low Bottom Bed of Fulledge. Shells near the holotype have been found on a lower horizon in the *communis* Zone at Sparth Bottoms, Rochdale.

Occasional specimens of *Anthraconaia*, comparable to a varying degree with *A. fugax*, range upward from the middle of the *lenisulcata* Zone. For example, small *Anthraconaia* cf. *fugax*, with height/length ratio of about 45 per cent. and having a slightly sinuous posterior margin (G.S.M. DM5144), was found above the Lower Mountain Mine in a borehole at Heskin, near Wigan (Calver *in* Magraw 1957, p. 37), and a similar but still smaller specimen, with length 16 mm. and H/L ratio about 39 per cent. (G.S.M. DM4569, '*A.* cf. *wardi* Hind pars sp.', Magraw 1957, p. 22), was found in flags between the Cannel Mine and Tonge's Marine Band in an adjacent boring. The shell shown in Plate 47, fig. 6, appears closely similar to *A. fugax* (see dimensions above), but has a posterior margin more comparable with that of the Wigan specimens. In Yorkshire, on a horizon about that of the Norton Musselband, a fragmentary *Anthraconaia sp.* (Eagar 1956, fig. 7*g*) is probably similar to the shell G.S.M. Bi 158 (*A. cf. fugax*) from 29 feet above the Norton Coal in Wingfield Manor Borehole (Eden 1954, p. 97). Similar shells (e.g. MM. LL2643) occasionally appear in the Glynneath Band.

In the lower *communis* Zone the shell shown in Eagar 1956, fig. 9*k* may belong to the *A. fugax* group, but those of figs. 9*g*, *i*, and *j* are considerably more expanded to the posterior than is *A. fugax* and appear more comparable with variants of the *A. modiolaris* group. On higher horizons, for instance at the base of the *modiolaris* Zone, laterally flattened shells (e.g. Wright 1938, figs. 4*c–e*) are probably not referable to the *A. fugax* group since the angle $\beta$ is very large. The same comment may be made on the fauna above the Flockton Thin Coal near Barnsley (Eagar 1961, fig. 4) where variation is considerable.

### *Naiadites hibernicus* sp. nov.

Plate 47, fig. 16; text-fig. 14A, B, D

*Diagnosis*. Shell small, carinate, with subtriangular outline, modified by a well-rounded postero-ventral margin and byssal sinus of varying strength. Umbones sharp, the beaks rising inappreciably above the line of hinge. The carina is strongest in the anterior third of the shell, its crest following a weakly sigmoidal line to run approximately parallel to the anterior ventral margin for the greater part of its length. In the posterior half of the shell the carina loses definition, flattening out towards the postero-ventral margin. The dorsal half of the posterior margin is straight or slightly sinuous and meets the hinge-line in a well-defined posterior dorsal angle. H/L, 64–80 per cent. T/L, 33–40 per cent. DM/L, 70–80 per cent. $\beta$, 120°–130°. $\gamma$, 42°–50°.